California Environmental Technology
Certification Program

Evaluation Report

Onboard Oil Management System

puraDYN Filter Technologies, Inc.

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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

HAZARDOUS WASTE ENVIRONMENTAL TECHNOLOGIES CERTIFICATION PROGRAM

ONBOARD OIL MANAGEMENT SYSTEM

Manufactured by:

puraDYN Filter Technologies Inc.

(formally known as **TF PURIFINER, INC.**)

Boynton Beach, Florida

TECHNICAL EVALUATION REPORT

(RECERTIFICATION)

JULY 1998

Version 1.4

FOREWORD

This report was prepared by the staff of Office of Pollution Prevention and Technology Development (OPPTD). Project leader for this technology re-certification is John Ison. Other contributors include Tony Luan, David Weightman, Ron Lewis, Clay Booher, Bruce La Belle, and Dick Jones.

Any questions regarding the technical content of this report should be directed to John Ison, of the Office of Pollution Prevention and Technology Development.

ABSTRACT

The puraDYN's Onboard Oil Management System (OOMS) is a bypass oil filtration system for internal combustion engines. An OOMS (previously known as Electric Mobile Oil Refiner), when used per manufacturer's instructions, can increase the interval between oil changes and thus reduce the generation of used oil. The OOMS is certified by the California Department of Toxic Substances Control (DTSC) as a Pollution Prevention technology. The decision to re-certify is based on data from analytical laboratories, field testing, diesel engine manufacturers, continuing data from users documented in the July 25, 1994 certification, and new users.

TABLE OF CONTENTS

LISTS OF TABLES

LISTS OF FIGURES

I. INTRODUCTION

Chapter 412, Statutes of 1993, Section 25200.1.5, California Health and Safety Code, enacted by Assembly Bill 2060, authorizes the California Department of Toxic Substances Control (DTSC) to certify the performance of hazardous waste environmental technologies. The purpose of the certification program is to provide an independent technical evaluation to facilitate regulatory and end-user acceptance. As part of this program, DTSC has evaluated puraDYN's Onboard Oil Management System (OOMS), a bypass engine oil filtration system and issued a certification that became effective July 25, 1994 (previously known as Electric Mobile Oil Refiner); the certification term was for three years. puraDYN requested DTSC to extend the original certification for one year or until a re-certification decision is made. This report includes puraDYN's improved modifications to a flow meter, location on oil sampling valve, and metering jet. The re-certification evaluation is based on the original 1994 certification's technical documents, data analyses from oil samples, and previous end-user interviews plus validation data submitted by the manufacturer plus current end-user interviews and data analysis from oil samples.

II. TECHNOLOGY DESCRIPTION

OOMS is an engine oil bypass purification system that extends oil drain intervals (see Figure 1 Page 23 for schematic of the OOMS and its installation). OOMS features a canister that can be mounted on the fire wall, fender well, engine, or frame of the vehicle, as long as the return line is above the oil pan. The canister inlet is connected to the engine's oil pressure sending unit or oil galley. The canister outlet is connected to the pan, engine block, or valve cover so that oil gravity feeds back into the engine oil system. The canister electric heating element is connected to an electricity source that supplies current when the engine is operated. The canister houses a disposable long-stranded cotton filter element and an evaporation chamber containing the heating element.

Engine oil enters the canister via a metering jet that restricts the flow to approximately six gallons per hour (previously the TF8SP model was restricted three gallons per hour). The oil passes though the cotton filter element where particles larger than one micron are removed. Filtered oil flows over a diffuser plate and is heated to approximately 195 degrees Fahrenheit in an evaporation chamber. Fuel, water and coolant evaporated by the heated diffuser plate vents to the air cleaner. The filtered and treated oil flows returns to the engine sump by gravity flow via a flow meter (previously a site glass) and return line.

III. CERTIFICATION STATEMENT

puraDYN's Onboard Oil Management System (previously known as Electric Mobile Oil Refiner) a bypass oil filtration system for internal combustion engines is certified by DTSC as a Pollution Prevention technology when installed, operated, monitored, and maintained according to puraDYN's standards and specifications. This certification is specific to reduction of engine oil usage and used oil generation (no life-cycle analysis was performed). The system has been shown to be an effective means of extending engine oil change intervals through the removal of particulate, water, and dissolved fuel. Extension of drain intervals reduce:

1) use of new oil,
2) generation of used oil, and
3) potential of spills while draining and transporting used oil.

If properly operated, monitored, and maintained, puraDYN's Onboard Oil Management System maintains the following engine oil properties within acceptable limits for continued use: viscosity and solids content, water, coolant, fuel, wear metals, and oil additives. These properties may not be maintained within acceptable limits if major system failures occur, such as: faulty head gaskets that leak coolant into the crankcase, faulty fuel injectors that leak fuel into the crankcase, oil cooler leaks, etc.

Engine oil drain cycles vary according to engine type, fuel quality, oil type, oil consumption rate, work environment, and engine loading. Extended oil drain cycles depend on elimination of harmful contaminants. Oil analysis is recommended as an essential tool in determining maximum drain intervals and as an early warning for excessive engine wear and/or possible engine failure.

IV. CERTIFICATION LIMITATIONS/DISCLAIMER

DTSC makes no express or implied warranties regarding puraDYN's products or equipment. Nor does DTSC warrant puraDYN's products or equipment to be free from defects in workmanship or material caused by negligence, misuse, accident or other causes.

DTSC does believe, however, that the manufacturer's product or equipment can achieve performance levels as described in the certification. Said belief is based on a review of three additional years of data from end-users, current and previous data submitted by the manufacturer, and interviews with current and previous end-users of the equipment who have used the equipment in accordance with the manufacturer's specifications.

Limited testing was conducted in 1994 under the direction of DTSC to confirm the data submitted by puraDYN or collected from other sources. In addition, limited testing was conducted by C.F. Services of Woodland, California for a demonstration project funded by a 1997 grant from the California Integrated Waste Management Board. No additional testing was performed by DTSC for the re-certification.

By accepting the certification, the manufacturer assumes, for the duration of the certification, responsibility for maintaining the quality of the manufactured equipment and materials at a level equal or better than was provided to obtain the certification. The manufacture also agrees to be subject to quality monitoring by DTSC as is required by the law under which the certification was granted.

V. ENGINE MANUFACTURER'S PRODUCT WARRANTIES

For the recertification evaluation, puraDYN provided copies of letters (see Appendix A) from eleven manufacturers that discussed the effect of using the OOMS on their respective engine warranties. The responses to the OOMS were similar and generally could be summarized as follows:

> The original engine warranties covers defects in workmanship and/or materials as manufactured, and use of after-market devices, such as the OOMS, does not, in and of itself, void the warranty. However, any engine performance problem or failure attributable to use of such devices will not be covered under the terms of the warranty.

If there are any questions concerning engine warranties, the end-user should consult their particular engine manufacturer to determine if using the OOMS will affect their engine warranty.

puraDYN offers a ten-year warranty on the OOMS; with one exception, the heating element warranty is five years. This warranty includes repair or replacement of the product itself and repair of damage to engines caused by the OOMS during the ten-year warranty period. This warranty is limited as specified in puraDYN's warranty statement (a copy of the warranty statement is included in Appendix D).

puraDYN has a certificate of liability insurance for one million dollars. This insurance covers any bodily injury or property damage arising out of the named insurer's product (a copy of the certificate of liability insurance is included in Appendix A).

VI. TECHNOLOGY EVALUATION AND CERTIFICATION BASIS

The evaluation's purpose was to determine if, by extending oil change intervals, the OOMS would reduce the generation of waste oil without adversely affecting engine wear or performance. The evaluation of the effect on engine wear included both qualitative information and quantitative data. The technology was evaluated from six different sources of information:

A. Vendor Supplied Information -

puraDYN supplied information included: information on a new flow meter and drawing, letters supporting TF Purifiner for the National Medal of Technology, brochures [includes information on oil's primary function, TF Purifiner describes why standard full flow filters cannot do the job, cut away view of puraDYN's filter assembly, list of applications, benefits, achievements, environmental benefits, certifications and awards, warranties, and specification of different models of puraDYN's filter system that includes capacities, flow rates, dimensions, shipping weight, and amperage draw for each type of model], lists of companies using the OOMS on diesel engines and gas engines, paper by Byron Lefebvre of puraDYN, supporting letters from end-users, and data from one end-user.

puraDYN also supplied information on their new TFP-Plus Filter that claims it can be used as a replacement to the original TF Purifiner filter element. puraDYN claims this new filter has built-in, time-release additive replenisher that compensates for any drop in the TBN (total base number) of the oil. The new TPF-Plus Filter was not considered in this certification evaluation.

B. How Does One Determine When Oil Is No Longer Good For Continued Use?

Various outside sources were consulted regarding the OOMS. The principal question addressed to outside experts was, how does one know when engine oil is no longer good for continued use? Telephone discussions, Internet search, literature search and other information supplied from these sources are attached to this report as Appendix C and Appendix E. Summaries of the discussions about oil and how to tell if it is still good from these sources are:

1) Most outside experts hesitated to specify measurement parameters to determine if an oil was still good or not. They were concerned that using specific criteria would oversimplify the question and would be used as "pass/fail" criteria. For instance, metal levels in engine oils can vary depending on numerous factors such as:

- engine metallurgy,
- dispersion characteristics of the oil's additive package (which help hold metals in suspension),
- filtration configuration,
- oil/lubricant consumption and replacement (which dilutes values)
- types of engine lubricants and additives (many lubricants and additives may contain metals such as aluminum, chromium, copper, and lead as trace ingredients)
- engine usage (light or heavy loads, long or short hauls)
- ambient conditions (summer versus winter conditions, ambient air contaminants).

These and other factors must be considered when evaluating whether an oil is good for continued use. Several outside experts indicated that rapid changes in contaminant metal concentrations or rapid fluctuations of other oil properties would be much more important in determining whether an oil was failing than a strict adherence to published ranges or criteria.

2) Care must be taken when evaluating metals analysis data. In 1994, two outside experts stated that standard spectrophotometer analysis for metals will not ionize particles greater than approximately two microns. Therefore, particles of greater size are not detected. However, particles greater than this size are more likely to cause frictional wear in engines because they are larger than typical engine tolerances. [Note: This could have significant implications when evaluating bypass oil filtration systems such as the puraDYN (TF Purifiner). Warning limits for engine oils were developed for engines using conventional oil filtration systems and oil drainage cycles. The puraDYN may remove the larger particles that damage engines but not the unharmful smaller particles that show up in a spectrophotometer analysis. Therefore, additional care/judgement is required when evaluating metal levels in systems using bypass oil filters].

3) The outside experts were also concerned that oil additive packages might become depleted when using a filtration system such as the puraDYN (TF Purifiner). They stated that the additive packages are designed to be depleted as they work, e.g., an additive to neutralize acids is consumed as it performs this function.

Note: In response to this concern, it should be pointed out that even when engine oils are not drained, engine oil is replenished when:

a) Oil is added to replace oil lost due to normal oil consumption of the engine, and

b) Addition of makeup oil is added when the flow-full and puraDYN filter elements are replaced. This is shown graphically in Figure 2 Page 24. This figure shows that for a typical scenario, over a period of 180,000 miles, an engine equipped with a OOMS consumes 254 quarts of oil compared to 678 quarts for an engine without a OOMS. This means that additive packages contained in new oil will be replenished partially by the addition of makeup oil. The figure also shows that the average "age" of the oil in the engine with a puraDYN is approximately three times that of the ultimate age of oil in a conventional drain cycle.

The outside experts have pointed out that determining whether an additive package is depleted is difficult because additive packages vary from one manufacturer to another and most analytical tools available do not directly measure the concentration of the additive package. The parameters that are typically monitored are viscosity, total base number (a measure of the oil's ability to neutralize acids), and the concentration of some elements (e.g., calcium, magnesium, phosphorus, sodium, and zinc that are part of many additives). The suggested methods for evaluating these parameters include confirming that:

a) The viscosity does not significantly change;

b) The total base number stays above a value of two; and

c) The concentration of elements, associated with additive packages, should be maintained.

The warning limits and typical oil properties obtained from the outside experts are summarized in Table 1. Note these levels were developed for engines with conventional oil drainage cycles and did not take into account the above discussed factors.

C. Customer Experience -

DTSC interviewed more than 20 puraDYN (TF Purifiner) customers about their experience with the OOMS. Specific information discussed included: number of units used, years of experience with the OOMS, vehicle/engine types, model year of vehicles, mileage on vehicles while using the TF Purifiner, oil filter change intervals, oil drain intervals, oil consumption rates, engine load factors, engine maintenance/repair information, and satisfaction/dissatisfaction with the product.

The customer survey included those who used the TF Purifiner on diesel trucks, gas trucks, off-road equipment and one user who continuously used the OOMS on a hydraulic press since 1981. All end-users contacted were satisfied with the product and would recommend the TF Purifiner's OOMS to other potential users of this technology.

1) End-users with Diesel trucks using the OOMS includes:

- One fleet of 150 trucks took only oil analysis samples at each regularly scheduled oil change intervals and replaced the full-flow filter, oil, and OOMS filter once a year. Some of the fleet reached mileage over 100,000 miles on a single oil/filter change; previous filter and oil change-out intervals ranged from 5,000 to 15,000 miles, depending upon engine size and make. The larger trucks reached one million miles or more.

- A customer, with a small diesel engine with 130,000 miles, changes the full-flow and OOMS filters and takes an oil sample every 6,000. The customer continues to run his engine without an oil change.

- A fleet of 6 trucks, each about to reach a million miles, changes the full-flow and OOMS filters every 300 hours without changing the oil. The oil analysis results confirm the oil to be normal.

- One customer dismantled two Mack engines to verify that extending oil change intervals did not reduce engine life. The oil had not been drained in more than two years with only filter changes every 2,000 gallons of fuel used. During the dismantling, the truck owner noted that the engine internals looked unusually clean. The main crankshaft and connecting-rod bearings were sent back to Mack trucks. Mack trucks found no appreciable wear on either the main crankshaft or connecting-rod bearings, however, the customer had the main crankshaft and connecting-rod bearings replaced when the engine was reassembled as a matter of policy.

- Another customer, with more than 80 trucks, has used TF Purifiner's OOMS for more than two years. The OOMS filter is changed every 20,000 miles. Oil changes occur every 60,000+ miles that include replacing the full flow filter and OOMS filter. The company has approximately 60 other older trucks that do not have the OOMS, but when the older trucks are replaced, OOMS will be installed.

- An owner of a truck fleet had doubts when the OOMS was first installed. Now, he wished he could afford an OOMS for every one of his trucks.

2) End-users with gasoline cars/trucks using the OOMS includes:

- Six customers had the OOMS installed on their cars and/or trucks with four to eight cylinder gas engines with mileage ranging from the 100,000 to 191,000. All customers only changed the oil filters and OOMS filter without an oil change. Most filter changes and oil analyses were at 6,000 miles intervals. All end-users were very pleased with results and would recommend the TF Purifiner's OOMS to anyone. None of the customers contacted had any negative experience with the OOMS. (See Appendix E).

3) Third party demonstration project:

The demonstration project was conducted by C. F. Services of Woodland California and funded by a grant from the California Integrated Waste Management Board. The demonstration successfully showed that the TF Purifiner Filter reduced the use of new oil in internal combustion engines. For specific results from the grant demonstration of end-users results regarding their experience with the TF Purifiner, see Appendix E. (For discussion, see section VI-E, below).

4) Hydraulic press applications included:

- The hydraulic oil has not been changed in a 150-ton press since 1979; prior to installing the TF Purifiner, the oil was changed after every 1,000 hours of operation with an average of 1,300 hours per year. From the past to the most recent oil analysis in 1997, laboratory analysis recommendations still state "Results of Tests Performed Indicate No Corrective Action Required."

- The hydraulic oil in 4 presses was drained and saved. The presses were moved and the used oil reinstalled. The two 300 ton presses and the two 600 ton presses continue to operate with the same hydraulic oil for more than two years. Although oil samples continue to come back normal, the filter changes and oil samples are done monthly.

5) For interviews of end-users conducted in 1994 regarding their experience with the TF Purifiner, see 1994 Volume II, Appendix D.

D. Customer-Supplied Data -

End-users provided data from typical real-world operating conditions. The data covered longer intervals of time, had a greater variety of uses, and had greater variety of conditions than those from a controlled test or demonstration. Several end-users and their oil analyses from independent laboratories, which had no commitment to puraDYN (TF Purifiner), helped make up the bulk the data used for re-certification. Some of these end-users' results were:

In 1997, DTSC reviewed the engine oil analysis data from Crumm Trucking, a longtime customer since 1988. See 1994 Appendix E and 1998 Appendix F for oil analysis reports. Crumm Trucking had a OOMS installed on each of their vehicles and never drained the oil from their engines. Mr. Gene Crumm supplied data on six trucks from his fleet; however only two trucks had more recent data then that of the 1994 certification evaluation. Mr. Crumm sold his company in 1996 and current records were not available on all of his trucks. (See Table 2 for a description of these vehicles). These two trucks have operated over 11,000 hours each while using the OOMS. Wear metal, viscosity, and other pertinent data on these trucks from the 1994 certification are summarized in Tables 3 and 4 and graphed in Figures 3a and 4a; for results for post 1994 certification, see Tables 3 and 4 and Figures 3b and 4b.

Data provided by Crumm Trucking were compared with the typical ranges and warning limits for engine oils. The data reviewed compared favorably for most of the criteria shown in Table 1. All data provided stayed within the criteria for water content, fuel content, and viscosity range. The levels for aluminum, chromium, iron, lead and silicon never exceeded any of their respective warning limits. Some levels for copper exceeded warning limits at times but not by significant margins. [Note, as discussed in Section B, there is some question regarding the appropriateness of applying these criteria to engines equipped with an OOMS]. Higher metal levels may be attributed to either: 1) the build up of small metal particles detected by the spectrophotometer that may not be large enough to be harmful to the engine, and 2) the high average "age" of the oil in these engines equipped with an OOMS. Additionally, as can be seen in Figures 3a, 3b, 4a and 4b, the metal levels varied with time but there were no sudden and sustained increases that would suggest a lubrication failure. Occasionally, an individual metal level might increase for a short duration and then later come back down to a more moderate level. Nevertheless, other metal levels did not have corresponding increases. This suggests that the increase in metal level may have been due to some outside factors such as the use of an additive that contains this metal, a contaminated sample, or the accuracy of the test method. The main factor from this data is that two trucks operated 11,000 and 12,000 hours respectively without oil changes and without any engine repair due to lubrication failure. Mr. Crumm reported all of the other trucks in the fleet had similar results before the company was sold.

G & K Services provided data on two trucks. One truck's data, unit 211, showed water (normal condensation) at 0.07% because the OOMS heater element was not working; the OOMS heater element was repaired. No oil was changed on unit 211 and the following oil analysis showed the percent water per volume to less than 0.05% (the laboratory's detection limit). This incident helps demonstrate that the TF Purifiner's OOMS heater element can provide water removal capabilities. The second truck, Unit 1683, had 1.5% fuel in the oil because of a clogged injector, oil was replaced and the injector repaired. Mr. Otrembiak of G & K Services reported both units continue to perform as expected although he wishes he could afford an OOMS for every one of his trucks. An important factor learned is the importance of oil analysis because the OOMS cannot be expected to remove abnormal quantities of contaminant when caused by a system failure such as a stuck or clogged injector. The OOMS has the capability of removing and maintaining acceptable contaminant oil levels for an extended period, under normal operating conditions. (See Appendix F for oil analysis results).

In 1992, Vulcan Chemicals leased ten new trucks with Caterpillar 3406 engines. An OOMS was installed on each truck. The oil samples taken, ranged with mileage from 12,000 to 24,000 miles per month. The oil analysis reports covered a six month period with a total of six samples per truck. All oil analysis reports were near the end of the lease cycle with just less than 600,000 miles on each truck. All oil analysis reports stated ALL LEVELS APPEAR NORMAL for the reported periods. Oil changes ranged from a minimum of two to a maximum of five oil changes over the life of service. Vulcan Chemicals reports that usually, oil was changed for other reasons than being required by oil analysis. For oil analysis reports see Appendix B. For tables and graphical representation see tables 6a through 6j and figures 6a through 6j. Several oil sample reports for Vulcan Chemicals had mileage gaps. Because of the consistent date intervals of samples and for graphical purposes, missing mileage was interpolated to help fill those gaps.

Before returning the leased trucks, each with just less than 600,000 miles, a dynamometer test was performed. All horse power engine performances were reached on the dynamometer test. One engine test was cut short because of engine overheating due to a faulty fan clutch. See Table 7 for data on all truck engines for hours on dynamometer, sustained horse power, and velocity maintained on each unit. See Figures 7a through 7j for graphs of Horse Power vs. Hours for each unit.

E. Independent Testing -

1) A demonstration project was funded by a grant from the California Integrated Waste Management Board. The project was carried out by C.F. Services. One objective of this project was to demonstrate the use of the OOMS to extend oil intervals.

The results gathered in the C.F. Services' report showed that the use of OOMS can drastically reduce the use of engine oil in a variety of internal combustion engines. The project also showed how well the OOMS worked on different pieces of equipment and on a large scale fleet.

A procedure was established that only the OOMS filters were changed at normal oil change intervals. No oil was drained, but the small amount left in the filters and for oil samples taken to verify condition of oil. Results from more than 140 oil samples were collected and analyzed. All the oil analyses' results were at normal acceptable levels, except when an engine experienced mechanical failure from a cause unrelated to the presence of the OOMS. Examples of exceptions are: water in the oil, oxidized oil, high silicon in oil, and fuel in oil are discussed below.

Highlights of the project were the hours reached on various types of equipment without changing the oil. Some of Sonoma County's compactors reached operating times of 2,271 hours that equated to 10 oil change maintenance cycles. Other pieces of equipment reached high operating times without oil changes, but in mid-February of 1997 with the oil still testing well for further use, the counties fleet management decided to change oil in landfill equipment. The reason for the decision was based in part on a 10-oil change maintenance cycle had been reached on the compactors. The project had successfully shown oil change intervals could be safely extended to the County's satisfaction. One other reason for an oil change was that the engine manufacturer's recommended main crankshaft and connecting rod bearings normal change-out period of five thousand hours were exceeded. A decision was made to replace the oil with new oil since it was drained for the bearing replacement. The landfill equipment is now working on new extended oil drain intervals.

The bearings from a Caterpillar 3306 Caterpillar engine operating in an 826C compactor were sent to Mr. Douglas Godfrey, Tribology Consultant. Four sets of bearings (2 connecting rod bearings and two main bearings) were inspected by the unaided eye and by a 40X microscope. The unaided eye examination revealed all bearings had low wear and were in good condition. Microscopic examination showed minor amounts of embedded black particles that accounted for dark colors and a trace of corrosion on rod bearings. The examination did not find severe abrasion, cracking and fatigue, peeling, wiping, severe corrosion and cavitation damage, or excessive embedment that are all common wear mechanisms in diesel engine bearings.

Since none of test vehicles from different departments that were taking part in the project had reached more than six extended oil maintenance cycles, a decision was made not to replace the oil then.

The report did confirmed six vehicles had oil changes that were due to engine mechanical failures. The six were:

a) Unit E-610, a 1994 Chevrolet Model 1500 pickup truck with a Chevrolet 350 CID, 8 cylinder gas engine. An OOMS was installed when the unit had 13,660 miles; the reference oil sample taken at the beginning of the project was abnormal. The sample showed a high reading of silicon and with a trace of water. At the required one-half maintenance interval at the start of the test, an oil sample revealed high water contamination. Oil was changed without mention of any repairs and the test restarted. Since the restart, oil analysis was normal for two consecutive oil analysis periods at which the project ended. Mileage at the end of the project was 19,022 miles.

b) Unit G-130, a 1979 International Model F-2574, three axle dump-truck with a Detroit 6V-92 diesel engine. An OOMS was installed when the unit had 213,495 miles, a reference oil sample, taken at the time the OOMS was installed, had a high silicon reading considered urgent by the Caterpillar Test Laboratory. Oil was changed twice during the project due to high silicon readings. The final oil sample taken on March 3, 1997 showed the silicon level had been reduced from the January 9, 1997 reading by 4 ppm to an acceptable level of 22 ppm. Since the last oil analysis without an oil change was at 32 ppm, the following oil analysis with its lower silicon level could not be attributed to an oil change, but to the OOMS. Mileage at the end of the project was 224,686 miles.

c) Unit G-303, a 1993 Ford Model F-350 utility truck with a Ford 7.3 liter, V-8 cylinder diesel engine. A model TF-12 OOMS was installed when the unit reached 74,113 miles. The truck's oil was changed once during the test period due to oxidation of the oil. Extreme high temperature causes oil to oxidize. The report did not mention repairs or the reason for the high temperatures, although the project ended with two consecutive oil analysis periods with normal results. The ending mileage, at the end of the project, was 87,261 miles.

d) Bus # 176, a 1986 Neoplan 44 passenger transit bus with a Detroit Model 6V-92, 6 cylinder diesel engine. A model TF-40 OOMS was installed when the unit had 169,238 miles. After two extended oil changes intervals, oil analysis showed fuel contamination at 3.25 percent caused by a leaky fuel system. Repairs were made and oil changed. The test was started over, resulting oil analyses showed oil in good condition until the end of test with 202,580 miles. The bus is operated daily by the Sonoma County Transit District.

e) Bus # 185, a 1986 Neoplan 44 passenger transit bus with a Detroit Model 6V-92, 6 cylinder diesel engine. A model TF-40 OOMS was installed when the unit had 15,892 miles. After two extended oil changes intervals, oil analysis showed fuel contamination at 4.13 percent. Because of a leaky fuel system and the oil analysis detected an additive package depletion, the oil was replaced. Repairs were made and the test was started over. At the end of the project, the resulting oil analyses showed oil in good condition at 51,050 miles. The bus is operated daily by the Sonoma County Transit District.

f) Unit J039, a 1994 Caterpillar Model D-9n Bulldozer Tractor with a Caterpillar Model 3408, 8 cylinder diesel engine. A model TF-60 OOMS was installed with starting hours at 5,440. After two extended oil changes intervals, with hours at 5,866, oil was changed due to scheduled warranty work at a recommended 5,000 hours. A second oil change was performed because the oil oxidized plus a low TBN. The oil oxidation had been encountered earlier in the project. Oil oxidation is likely caused from overheating the oil. The report did not mention repairs or the reason for the high temperatures, although the project ended with two oil changes and eight maintenance intervals without needing oil changes. Total hours on the engine at the end of project was 7,361 hours.

The summary of objectives from the demonstration project describes the different types of installations on a variety of equipment and how installations ranged from simple to difficult. The summary also discussed how results from random sampling by United Testing Group in Reno corroborated sample results from the Herguth Labs in Vallejo. One purpose from this demonstration was to show that the OOMS reduced waste oil generation overall. Results showed that the OOMS prevented 4,120 quarts of oil from entering the waste stream simply by extending the oil drain intervals.

The demonstration project included:

22 trucks (types: long bed, dump, flatbed, sign, water, and service)
4 pickup trucks
13 buses
3 scrapers
2 bulldozers
2 compactors

The demonstration project, performed by C. F. Services of Woodland California, successfully shown that the OOMS reduced the use of new oil in internal combustion engines. For specific demonstration results regarding end-users experience with the OOMS, (see Appendix E).

2) In 1994, DTSC evaluated oil analyses from the Crumm trucks discussed in Section VI-D, above (see 1994 Volume II, Appendix F for complete laboratory reports of DTSC directed testing). Some of this testing was paid for by Chevron Research and Technology Company (Chevron is the manufacturer of the oil used by the other of the two truck fleets involved in the 1994 tests). The testing also included analysis of new oil used by the respective customers.

The 1994 data showed that the properties of the oil from engines using OOMS for extended periods, without draining the oil, compare favorably with the warning limits shown in Table 1 and with the values for new oil. All data stayed within the warning limits for water content, fuel content, and viscosity range. The levels of elements associated with additive packages (calcium, magnesium, phosphorus, and zinc) were similar to that found in new oil. The total base number remained well above the minimum value of two, indicating that the oil was maintaining adequate levels of the acid-neutralizing components of the additive packages. The levels for aluminum, chromium, and silicon never exceeded any of their respective warning limits. In a few instances, the levels for copper, iron, and lead exceeded the warning limits but not by significant margins. As was discussed in Section VI-B, this result is acceptable when the limitations of spectrophotometer analysis and operation of the OOMS are considered.

F. Internet information. Internet and World Wide Web (www) searches were conducted using key words related to "oil analysis," "extended oil drain intervals," and "oil filters."

All Internet information found, which discussed extending oil drain intervals, identified oil analysis to be the most important feature in determining when or if oil should be replaced. All articles referred to oil analysis to be a worthwhile investment that can provide information on the engine history and help predict future engine performance. Listed below are some articles from two sources:

1) Diagnetics provide a Proactive Maintenance services which takes action against the sources of failure. Diagnetics contend that contamination of oil is the most common culprit for failure. The major fluid contamination is related to particles, moisture, heat, glycol and additive degradation, all of which can be monitored and controlled with a program of rigid contamination control practices. Diagnetics contends that with rigid contamination control practices, fluids and lubricants can last indefinitely, which in turn prolongs the life of the machine's components and keep the machine running at the highest level of efficiency.

Diagnetics states that its basic contamination control program can be implemented in three steps:

a) Establish the target fluid cleanliness levels for each machine fluid system.
b) Select and install filtration equipment (or upgrade current filter rating) and contamination exclusion techniques to achieve target cleanliness levels.
c) Monitor fluid cleanliness at regular intervals to achieve target cleanliness levels.

Diagnetics has articles listed on the Internet which cover:

a) Proactive maintenance.
b) Contamination monitoring for maximum uptime.
c) Optimizing the quality of data captured during oil sampling.
d) Three dimensions of fluid condition management.
e) Moisture -- the second most destructive lubricant contaminant, and its effects on bearing life.
f) Glossary of lubrication, filtration and oil analysis terms.
g) A booklet, that is mailed, called "The 10 Most Common Reasons Why Oil Analysis Programs Fail and the Strategies that Effectively Overcome Them."

2) Dalalahti Matti discusses a Finnish car magazine "Tuulilase" which tested 11 full flow filters by consecutively adding 15 mg per liter of test dirt for each pass through each filter. The test dirt consisted of particles smaller than 200 micrometers. The oil flow rate was 25 liters per minute. Results from all full flow filters varied but none removed particles less than 10 micrometers. Test results after five minutes and after ten minutes showed the particle size removal rate varied for particle sizes 40, 30, 20 and 10

micrometers. None of the filters achieved a 100 percent removal rate for any of the particle sizes. The results of this test showed how various sizes of particles were still passing through different filters. Tests results also have shown all filters became blocked from 13 to 25 minutes into the test to the point where the bypass valve opens and any remaining particles were able to flow freely pass the filter element. From the results shown above, systems with only full-flow filters are limited in the size and amount of particles that can be removed.

VII. OPERATION AND MAINTENANCE REQUIREMENTS

In engine applications using the model # TF 8SP, the unit is designed for oil sumps up to eight quarts in capacity. puraDYN's servicing recommendations state that the OOMS oil filter element be replaced every 12,000 miles or 300 hours or as oil analysis dictates after an initial one half normal interval. Also in engine applications using model # TF 8SP, puraDYN's OOMS servicing recommendations state that the standard full-flow oil filter should be replaced every 50,000 miles or 1,250 hours or once a year, whichever comes first. In all other OOMS models, puraDYN's servicing recommendations state that after the first one half normal interval, change the OOMS filter element at a normal periodic maintenance interval or as oil analysis dictates. puraDYN also suggests the OOMS be changed every 12 months or 60,000 miles or 1,500 hours which ever comes first. puraDYN suggests no oil changes unless specified in an oil analysis report.

The installation manual, parts list, and extended oil drain schedule for OOMS are included in Appendix G.

VIII. REGULATORY CONSIDERATIONS

The California Air Resources Board has determined that installing the puraDYN will not "reduce the effectiveness of the applicable vehicle pollution control system and, therefore is exempt from the prohibitions of Section 27156 of the Vehicle Code for installation on all 1993 and older model-year vehicles with pressure oil systems." (See 1994 Volume II, Appendix H)

Used oil and oil filter elements are presumed to be hazardous wastes, unless determined to be nonhazardous, and must be properly managed via disposal at certified oil collection centers or permitted facilities. The standard full-flow used oil filter elements may be crushed in a way that recovers any resulting used oil and then recycled for metals recovery without obtaining a hazardous waste treatment permit. Used oil from extended drains and from crushing of oil filter elements must be transported to a permitted used oil recycling facility. DTSC's Resource Recovery Unit may be contacted at (916) 323-6042 for more information on recycling of used oil and oil filters.

IX. CONCLUSION

Although DTSC did not receive data on each of the listed applications by puraDYN (such as; locomotives and military vehicles), DTSC did receive sufficient data on most of applications to render a decision for certification. DTSC bases it decision on information supplied by end-users and the accumulated data on gas engines and diesel engines used in various sized of cars, trucks, and boats that have shown that the OOMS can extend oil drain intervals.

Also, puraDYN's commitment to provide a quality product, maintain and improve their product, and backup their product with a 10-year warranty and a million-dollar certificate of liability insurance, provides added confidence in regard to their claims.

X. SUMMARY OF APPENDICES

1998 appendices of the Final Report is divided into lettered appendices that contain the supporting documentation used to certify the OOMS. The following summarizes these Appendices.

Appendix A contains information related to product warranties:

- A copy of puraDYN's (TF Purifiner's) ten-year limited warranty and a copy of their $1,000,000 product liability insurance policy against engine failure claims due to the installation of the puraDYN; and

- Letters from eleven different engine manufacturers responding to a TF Purifiner; Inc. inquiry regarding how the TF Purifiner will affect their engine warranty. The engine manufacturers include Caterpillar, Inc.; Mack Trucks, Inc.; Cummins Engine Company, Inc.; Ford Motor Company; Hyster Company; Yale Materials Handling Corporation; Clark Materials Handling Corporation; Tug Manufacturing Corporation; United Tractor; Elpar Materials Handling Equipment; and Detroit Diesel Corporation.

Appendix B contains testimonials, awards and nominations for the technology:

- Testimonial letters from the Houston Post; Hialeah Metal Spinning, Inc.; The Cousteau Society; Wildfire Express, Inc; Exploration Inc.; Coca Cola Enterprises Inc.; Vulcan Materials Company; and Florida Association for Pupil Transportation.

- A letter containing supporting data from testing conducted by Vulcan Chemicals.

- Awards presented to TF Purifiner:
    - 1996 (Florida) National Society of Professional Engineers (NSPE) New Product Award for a Small Business Category.
    - 1995 (Florida) Governor's New Product Award in Small Business Company Category.
    - Off-Highway Engineering's "Readers' Choice: Top 50 Products of the Year" (1996 December issue).
- Letter supporting TF Purifiner for the 1997 Medal of Technology by:
  James M. Strock, Former Secretary for Environmental Protection,
  Douglas R. Webb, Vulcan Chemicals,
  David C. Jones, National Education Corporation,
  Joyce L. Shields, VP & GM, Hay Management Consultants, and
  Ted Danson, Actor and President of American Oceans Campaign.
- Letter from Perry Croyle - Pennsylvania Department of Transportation that discusses testing on Mack engines.

Appendix C contains miscellaneous Internet information related to the technology:

- Articles from the Internet and World Wide Web:
    - Diagnetics On-Site Oil Analysis Experts - discusses oil analysis, sampling, contamination, effects, and maintenance.
    - Citgo Citgard™ 600 Motor Oils Lubricants Products Information - discusses lubricant life over longer change intervals or when using fuels of higher sulfur content.
    - Brian L. Sydness discusses Oil Analysis Results and Options and tests conducted.
    - Finnish car magazine "Tuulilasi" compares oil filters in July 1995 issue that discusses particle removal size.

Appendix D contains miscellaneous information related to the technology:

- Trade magazine articles:
    - Fleet Equipment, January 1997 - Volume 23 - Number 1 - Article called Pushing Oil Drains.
    - Equipment World, December 1996 - Volume 8 - Number 12 - Article called New Filters Meet New Demands and article called Realize Your Cost-Saving Strategy.
    - Diesel Progress Engines & Drives, December 1996 - Article called Hydraulic Systems Trends.
- A Society of Automotive Engineers (SAE) paper by Byron Lefebvre, October 17-20, 1994, discusses Impact of Electric Mobile Oil Refiners on Reducing Engine and Hydraulic Equipment Wear and Eliminating Environmentally Dangerous Waste Oil;
- TF Purifiner literature and product specifications including: General Specifications, Achievements, Environmental Benefits, Certification and Awards, and Applications, Questions and Answers on the TF Purifiner, Cost Benefit Ratio Information, and four magazine advertisements.

Appendix E contains telephone logs of interviews of TF Purifiner end-users and parties consulted outside the certification program:

- Grant Townsend: Mr. Townsend's Mercury eight cylinder engine has 151,000 miles. OOMS was installed at 100,000 miles. Plans to continue without any oil changes. "Sold" on the product.
- Alfred Ditizio: Mr. Ditizio Chevy Blazer's diesel engine, with 130,000 miles, changes the OOMS filter at 6,000 miles and sends in an oil sample, but does not drain the oil. Mr. Ditizio is extremely happy with the OOMS.
- Crumm Trucking: (Mr. Crumm was the owner of Crumm Trucking and was one of two fleets from which data was used for the 1994 TF Purifiner certification evaluation. Mr. Crumm sold his trucking firm in late 1996). Mr. Crumm said he had excellent results that helped save money. He highly recommends the OOMS to everyone.

- Lawrence Gavin: Mr. Gavin's La Baron has 123,000 miles total miles but only 23,000 miles with the OOMS. He changes only the filter and sends in an oil analysis but does not drain the oil. Very happy with the results.

- Hialeah Metal Spinning: Karla Arron VP & General Manager says the 150-ton press continues to have great results with the oil analysis samples since the OOMS was first installed in 1988. The 1979 press has a 400-gallon capacity. Prior to installing the OOMS, Hialeah changed oil every 1,000 hours and averaged 1,300 hours of operation per month.

- Pilgrim Pride Poultry: Mr. Cox is in charge of a fleet of 1,500 trucks, of which, 150 are fitted with an OOMS. All filters are changed every 15,000 miles and oil at 45,000 miles. Trucks average 1,000,000 miles before they are replaced with new trucks.

- Precision Printing and Packaging (formerly Merico Trucking) Mr. George Robinson: Precision has three trucks with more than 1,000,000 miles. One Cummins 300 engine was rebuilt at 900,000 miles, one had the oil changed due to antifreeze contamination from a blown head gasket. Except for the previously mentioned, there were no other oil changes. Mr. Robinson also had 16 trucks previously with an OOMS but had too reduced the fleet. Had great results in the past and still is getting great results.

- Larry Sost: Mr. Sost recently sold his 1993 Ford, 5.0 liter gas truck with 191,000 miles and purchased a new 1997 Ford, 5.4 liter gas truck. He installed a OOMS on his 1993 truck at 60,000 miles and no longer drains the oil (131,000 miles without an oil change). He has installed a new an OOMS on the 1997 Ford and has no plans of changing the oil.

- Ron Darling: Mr. Darling has several vehicles: 1955 Chevy, 6 cylinder engine with two years on the oil (approximately 20,000 miles), 1992 Isuzu, 4 cylinder engine with 80,000 miles. An OOMS was installed on a 1985 Chevy stepvan, 454 cubic inch 8 cylinder engine at 25,000 miles (now with 55,000 miles without an oil change); 1987 GMC PU, 8 cylinder engine averages 12,000 miles per year; and a 1986 Lincoln, 8 cylinder engine averages 25,000 miles per year. None of the above has had their oil changed.

- Ft. Worth Carriers/Dillard Stores: John Luttrell has been using the OOMS for more than two years. Mr. Luttrell has approximately 60 other trucks that do not have an OOMS because they are older trucks but when they are replaced, the new trucks will have the OOMS installed.

- Blackbeards Cruises: Mr. Gary Flemming has four boats, three with Ford 380 cubic inches engines and one with two Isuzu engines, one for driving a generator and the other for the drive engine. All drive engines are three years old and average 1,800 hours per year. The generator averages 7,800 hours per year. Oil is changed if any abnormalities are found in the oil analysis. Mr. Flemming says he is happy with the OOMS. He has had only one problem with one o-ring which leaked. The o-ring was replaced and has had no other problems.

- Harold Paulson: Mr. Paulson has a 1993 GMC with 80,000 Km (50,000 miles). He installed an OOMS at 50,000 Km. Since then, he has not changed the oil. He plans to continue without any oil changes.

- Coca Cola Bottling Company: Ronnie Moore uses Quakerstate 15-40 and has had great oil analysis results. He plans to continue the practice yearly oil changes with an oil analysis at the oil change interval specified by the engine manufacturer. He highly recommends the product.

- Oak Farms Dairy: Mr. Klein had experience with an OOMS with Super Value Grocery chain. He is sold on the product.

- Commonwealth of Pennsylvania: Mr. Coyle has tested the OOMS for two years on new 1995 Mack trucks. No oil changes, filter changes every 2,000 gallons of fuel consumed. After 2 years, tore down engines and sent bearing back to Mack trucks. No appreciable wear was found on bearings. Bearings were replaced because the engine was already dismantled for inspection. He is satisfied with results obtained from using the OOMS.

- Vulcan Chemical: Mr. Webb said the OOMS is working great. Oil samples were performed by both TF Purifiner and Caterpillar . Caterpillar was satisfied with the results and now the samples are performed just by TF Purifiner. Mr. Webb said he was very happy with the product.

- Notes from telephone conversations with Dave Wheetman and Keith Spoonmore of Texaco Oil Products with general comments on engine oil analysis and extended oil intervals; Mr. Wheetman is doing testing on a new oil which may extending drain intervals up to 30,000 to 40,000 miles (new TC7 oils). Mr. Wheetman feels with the newer engines operating at higher temperatures, water and fuel contaminants will be driven off through the crankcase vent tube. Longer drain intervals are being accomplished by adding specific additives targeted as wear agents, antioxidants, and corrosive inhibitors that have a higher degree of disbursents. Mr. Wheetman says care must be taken because different additive levels are needed for different engines and the type of use to which they are subjected. Mr. Keith Spoonmore also says that Texaco does not set limits for

TBN; they may be set by engine manufacturers but those limits are only a reference. Mr. Spoonmore commented that trending of the oil analysis will be the determining factor when it comes to extended oil intervals. (Trending - keeping track of levels from each oil analysis and noting any variations)

- Note from a telephone conversation with Leif Peterson of California Environmental Protection Agency, Department of Toxic Substances Control confirming his concerns regarding the evaluation of the OOMS.

Appendix F contains the engine oil analyses provided by end-users of the TF Purifiner:

- 10 oil sample analyses from two G & K Services trucks;
- 3 oil sample analyses from Hialeah Metal Spinning, Inc.'s 150 ton press;
- 60 oil sample analyses from six Crumm Trucking trucks;
- 60 oil sample analyses from ten Vulcan Chemicals trucks.
- 8 oil sample analyses from Ford Motor Company's presses.

Appendix G contains the installation manual for puraDYN (TF Purifiner), parts list, and extended oil drain schedules.

Appendix H contains the engine oil sample analyses by Lubricon Consultants.

Appendix I contains a report by the California Air Resources Board, Evaluation of puraDYN, Inc. Mobile Oil Refiner for Exemption from the Prohibitions of Vehicle Code Section 27156 in Accordance with Section 2222, Title 13, of the California Code of Regulations.

Table 1. Typical Ranges and Warning limits for Engine Oils

Ranges are from the 1994 Certification Volume I

	Lubricon's "Typical Ranges" for Oil in Diesel Engine	Lubricon's "Action Levels" for Oil in Diese Engine	Texaco's "Warning Limits" for Oil in Diesel Engine	Titan Labs' Warning Limits for non-Cummins Diesel Engine	Titan Labs' Warning Limits for Cummins Engine
Aluminum, ppm	2-20		30	21	21
Chromium, ppm	0-20		30	11	11
Copper, ppm	5-65		40	26	26
Iron, ppm	3-150		100	150	50
Lead, ppm	3-50		100	25	25
Silicon, ppm	1-15		20	18	18
Water, %			0.3		
Fuel Dilution, %	0.5-1.5	1.5 to 2.0	3		
Total Base Number		2 or less	2 or less		
Viscosity Increase		18%	35%		
Viscosity Decrase		12%	25%		

Table 2.

Description of Fourteen Trucks, used in the 1998 Technology Evaluation
Two Crumm Trucks were also used in the 1994 Technology Evaluation and again in the 1998 Technology Evaluation.

Unit #	22	26	1683	211	114	115	116	117	118	119	120	121	122	123
Owner	Crumm	Crumm	G & K	G & K	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan	Vulcan
Vehicle Maker	Ford	Ford	Int'l	Chevy	Volvo	Volvo	Volvo	Volvo	Volvo	Volvo	Volvo	Volvo	Volvo	Volvo
Vehicle Model	F7000	L8000	8100	P30	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.
Year	1987	1987	1993	1993	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992
Engine Maker	Cat	Ford	Cummins	Chevy	Cat	Cat	Cat	Cat	Cat	Cat	Cat	Cat	Cat	Cat
Engine Model	3208	L8000	L10	350	3406	3406	3406	3406	3406	3406	3406	3406	3406	3406
Fuel Type	Diesel	Diesel	Diesel	Gas	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Hp	170	240	300	155	400	400	400	400	400	400	400	400	400	400
Manufacture's recommended oil change intervals	200 hrs or 6000 miles	300 hrs or 10,000 miles	15,000 miles	3,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles	15,000 miles
Oil sump cap	12	36	40	5	40	40	40	40	40	40	40	40	40	40
Filter installed:														
Date	10/22/88	02/23/88	1993	1993	1992	1992	1992	1992	1992	1992	1992	1992	1992	1992
Hours	2,299	1,039	NG	NG	New	New	New	New	New	New	New	New	New	New
Current Hours														
Date	09/03/96	02/21/96	09/02/97	06/10/97	10/21/95	09/17/95	10/27/95	09/17/95	11/05/95	10/14/95	10/20/95	11/05/95	10/29/95	10/29/95
Hours	12,479	11,211												
Mileage			225,314	75,347	577,778	592,351	575,548	574,608	594,000	621,032	589,645	604,212	583,787	602,510

NG = Not Given

Table 3. Data on Crumm Trucking, 22

	Unit #	Date	Hours On Oil	Viscosity cs-100C	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
1994 Certification	22	11/25/88	320		A	T	T	A	53	8	1	2	2	3
	22	01/24/89	644		A	T	T	A	88	16	22	NIL	7	7
	22	03/22/89	944		A	T	T	A	122	24	17	2	5	7
	22	05/17/89	1,252		A	T	T	A	155	27	29	2	8	10
	22	07/25/89	1,558		A	T	T	A	153	15	5	2	3	6
	22	09/12/89	1,861		A	T	T	A	139	11	NIL	NIL	8	4
	22	11/03/89	2,156		A	T	T	A	138	12	NIL	NIL	4	6
	22	01/22/89	2,469		A	T	T	A	149	16	1	2	2	6
	22	03/23/90	2,780		A	T	T	A	153	16	24	3	15	10
	22	07/03/90	3,084		A	T	T	A	107	17	5	2	5	12
	22	11/27/90	3,414		A	T	T	A	110	13	33	5	15	5
	22	05/23/91	3,722		A	T	T	A	94	14	20	3	7	11
	22	11/15/91	4,034		A	T	T	A	60	5	4	1	3	1
	22	04/03/92	4,341		A	T	T	A	77	5	5	1	3	5
	22	08/04/92	4,692		A	T	T	A	64	6	0	1	2	4
	22	11/12/92	5,023		A	T	T	A	77	6	6	1	3	6
	22	04/07/93	5,353		A	T	T	A	94	8	8	1	3	6
	22	09/07/93	5,631		A	T	T	A	93	6	9	1	4	6
Post Certification	22	04/26/94	8,719	13.0	1	T	1	A	89	5	10	1	3	9
	22	02/03/95	9,058	13.5	1	T	T	A	86	5	12	1	4	8
	22	04/05/95	9,037	14.4	1	T	T	A	71	5	10	1	3	7
	22	06/09/95	10,367	14.1	2	T	T	A	75	4	12	1	4	5
	22	08/23/95	10,367	14.8	2	T	T	A	67	6	19	1	4	4
	22	10/25/95	10,690	14.6	2	T	T	A	68	4	7	2	3	6
	22	01/11/96	11,010	13.9	2	T	T	A	73	5	9	2	4	7
	22	03/20/96	11,362	13.5	A	T	T	A	60	3	11	1	3	5
	22	05/30/96	11,696	15.7	1	T	T	A	62	3	10	2	3	5
	22	09/03/96	12,159	15.3	1	T	T	A	65	3	13	1	3	5
	Ave Hours Per			Averages of new data only					72	4	11	1	3	6
	Filter Hours		305	Std Deviation of new data					9	1	3	0.5	0.5	2

T = Trace (<.5%water,<5%fuel, or <7%diesel), A = Acceptable(< 28 abs/cm varnish)

Table 4. Data on Crumm Trucking, Unit 26

	Unit #	Date	Hours On Oil	Viscosity, cs-100C	Solid %	Water %	Fuel, % Dilution	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
1994 Certification	26	04/26/88	322		A	T	1	A	12	5	NIL	NIL	3	2
	26	06/25/88	699		A	T	1	A	21	11	6	NIL	11	3
	26	08/23/88	1,058		A	T	T	A	29	21	NIL	NIL	4	2
	26	11/01/88	1,407		A	T	T	A	56	35	20	3	6	4
	26	01/06/89	1,753		A	T	1	A	42	25	13	3	9	4
	26	02/24/89	2,062		A	T	T	A	42	23	1	2	5	2
	26	04/17/89	2,353		A	T	T	A	50	26	24	4	9	5
	26	06/08/89	2,669		A	T	1	A	49	24	15	2	12	4
	26	07/25/89	2,966		A	T	1	A	63	33	14	2	6	4
	26	09/29/89	3,282		A	T	1	A	60	32	16	4	13	4
	26	11/21/89	3,581		A	T	1	A	57	30	17	4	4	5
	26	01/25/90	3,878		E	T	T	A	41	23	42	6	13	5
	26	02/09/90	3,964		A	T	T	A	37	26	28	4	12	4
	26	04/09/90	4,194		A	T	T	A	45	27	17	4	11	5
	26	07/03/90	4,524		A	T	1	A	51	26	12	4	7	7
	26	09/26/90	4,834		A	T	1	A	39	25	1	2	2	13
	26	11/27/90	5,110		A	T	1	A	67	37	35	7	18	4
	26	02/12/91	5,407		B	T	1	A	42	20	NIL	2	12	NIL
	26	04/16/91	5,710		B	T	1	A	48	18	14	4	15	3
	26	07/08/91	6,009		B	T	1	A	52	20	11	3	12	5
	26	09/11/91	6,313		E	T	1	A	63	30	17	4	15	7
	26	11/26/91	6,614		A	T	1	A	60	19	9	4	5	6
	26	03/22/92	6,914		1.0	T	1	A	71	22	13	4	5	7
	26	09/03/92	7,246		2.0	T	2	A	66	24	11	4	5	5
	26	03/01/93	7,556		2.0	T	2	A	76	30	18	5	6	6
	26	10/30/93	7,880	12.5	1.0	T	1	A	61	29	14	4	5	5
Post Certification	26	03/23/94	8,965	12.8	1.0	T	1.	15.2	55	27	12	3	4	5
	26	09/27/94	9,260	12.9	1.0	T	1	18.7	65	30	20	4	5	6
	26	12/21/94	9,597	12.6	1.0	T	1	19.5	60	27	16	4	5	12
	26	02/27/95	9,890	13.2	1.0	T	0	14.6	57	27	21	3	5	10
	26	05/03/95	10,195	13.8	1.0	T	0	23.6	54	26	15	3	5	7
	26	07/18/95	10,534	14.4	1.0	T	0	20.8	57	28	16	3	5	6
	26	12/06/95	10,884	13.4	1.0	T	0	24.3	40	21	11	3	5	5
	26	02/21/96	11,211	13.0	1.0	T	1	21.0	45	23	10	3	5	6
	Ave Hours Per			Averages of new data only				20	54	26	15	3	5	7
	Filter Hours		305	Std Deviation of new data				3	8	3	4	0.4	0.3	2

Ave. Hours Per Filter Change = 305 T = Trace, A = Acceptable, B = Borderline, E = Excessive

T = (<.5%water, <5%fuel, or <7%diesel) A = (<28 abs/cm varnish)

Table 5a. Data on G & K SERVICES

UNIT No. 1683

Unit #	Date	Miles On Oil	Viscosity, cs-100C	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
1683	12/12/96	200,624	12.48	2	T	T	N/G	8	20	5	4	2	4
1683	02/07/97	205,241	10.73	1.5	T	1.5	N/G	8	8	8	1	4	3
1683	05/16/97	209,711	12.61	2	T	T	N/G	14	4	1	4	1	2
1683	06/10/97	217,334	13.08	1	T	T	N/G	4	1	1	4	3	3
1683	09/02/97	225,314	11.5	3	T	T	N/G	12	3	6	3	6	4
		Averages	12.08	1.9				9	7	4	3	3	3
		Std Dev	0.85	0.7				3	7	3	1	2	1
Ave. Hours Per Filter Change		6,172											

T = Trace, N/G = Not Given

Table 5b. Data on G & K SERVICES

UNIT No. 211

Unit #	Date	Hours On Oil	Viscosity, cs-100C	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
211	11/18/96	331	12.45	0.3	T	T	N/G	15	19	7	2	4	5
211	12/26/96	1,578	13.1	0.5	T	T	N/G	13	20	2	4	3	5
211	01/21/97	3,129	12.11	0.5	T	T	N/G	15	16	6	4	6	5
211	03/14/97	6,367	12.97	1	0.07	T	N/G	34	7	14	5	7	9
211	06/19/97	10,021	12.96	1	T	T	N/G	32	5	12	12	8	12
		Averages	12.72	0.7				22	13	8	5	6	7
		Std Dev	0.4	0.3				9	6	4	3	2	3
Ave. Hours Per Filter Change		2,422											

T = Trace, N/G = Not Given

Table 6a. Data on Vulcan Chemicals

Unit 114

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
114	06/28/95	514,769	14.70	N/G	P	0	N/G	36	7	14	1	4	6
114	07/14/95	527,371	13.30	N/G	P	0	N/G	19	3	17	1	4	3
114	07/29/95	539,973	14.50	N/G	P	0	N/G	18	2	17	3	3	2
114	08/25/95	552,575	15.90	N/G	P	0	N/G	12	3	15	6	8	6
114	09/24/95	565,176	12.60	N/G	P	0	N/G	42	4	14	8	9	5
114	10/21/95	577,778	13.30	N/G	P	0	N/G	20	19	5	1	2	7
		Averages	14.05	0.7				25	6	14	3	5	5
		Std Dev	1.1	0.3				11	6	4	3	3	2
Ave. Hours Per Filter Change		12,602											

N/G = Not Given, P = Pass

Table 6b. Data on Vulcan Chemicals

Unit 115

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
115	04/29/95	498,005	15.00	N/G	P	0	N/G	75	10	22	0	1	2
115	05/26/95	513,624	14.60	N/G	P	0	N/G	25	10	12	1	2	5
115	06/25/95	532,349	14.50	N/G	P	0	N/G	53	6	20	1	2	6
115	07/22/95	552,350	15.00	N/G	P	0	N/G	35	6	19	2	6	8
115	08/25/95	572,351	13.60	N/G	P	0	N/G	25	1	15	4	8	11
115	09/17/95	592,351	14.20	N/G	P	0	N/G	24	1	21	10	10	12
		Averages	14.5					40	6	18	3	5	7
		Std Dev	0.5					19	4	4	3	3	3
Ave. Hours Per Filter Change		18,869											

N/G = Not Given, P = Pass

Table 6c. Data on Vulcan Chemicals

Unit 116

Unit #	Date	Miles On Engine	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum . ppm	Silicon ppm
116	07/02/95	516799	14.30	N/G	P	0	N/G	93	20	5	0	3	10
116	07/16/95	525682	11.70	N/G	P	0	N/G	74	17	12	8	4	9
116	07/29/95	538148	15.20	N/G	P	0	N/G	31	3	8	6	2	4
116	08/26/95	550615	16.00	N/G	P	0	N/G	69	12	15	3	8	9
116	09/24/95	563082	15.40	N/G	P	0	N/G	95	15	21	4	9	13
116	10/27/95	575548	16.10	N/G	P	0	N/G	55	14	2	1	2	7
		Averages	14.78	0.7				70	14	11	4	5	9
		Std Dev	1.5	0.3				22	5	6	3	3	3
Ave. Hours Per Filter Change		12,467											

N/G = Not Given, P = Pass

Table 6d. Data on Vulcan Chemicals

Unit 117

Unit #	Date	Miles On Engine	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
117	04/29/95	503139	13.30	N/G	P	0	N/G	50	5	11	2	3	6
117	05/26/95	516472	13.70	N/G	P	0	N/G	46	9	10	1	4	7
117	06/25/95	532293	13.90	N/G	P	0	N/G	66	16	15	2	7	10
117	07/22/95	544834	14.70	N/G	P	0	N/G	6	2	7	5	3	0
117	08/25/95	559555	14.90	N/G	P	0	N/G	68	29	22	9	9	13
117	09/17/95	574608	14.50	N/G	P	0	N/G	42	33	10	2	3	5
		Averages	14.17					46	16	13	4	4	7
		Std Dev	0.57					20	12	5	3	3	4
Ave. Hours Per Filter Change		14,294											

N/G = Not Given, P = Pass

Table 6e. Data on Vulcan Chemicals

Unit 118

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
118	06/16/95	518,314	15.60	N/G	P	0	N/G	18	4	6	0	1	3
118	07/08/95	527,174	14.70	N/G	P	0	N/G	44	11	11	1	4	6
118	08/11/95	543,880	14.90	N/G	P	0	N/G	36	5	15	5	5	7
118	09/09/95	560,587	13.90	N/G	P	0	N/G	66	7	13	8	9	10
118	10/06/95	577,294	14.30	N/G	P	0	N/G	37	8	17	8	8	5
118	11/05/95	594,000	14.70	N/G	P	0	N/G	60	18	0	2	4	7
		Averages	14.68					44	9	10	4	5	6
		Std Dev	0.52					16	5	6	3	3	2
Ave. Hours Per Filter Change		15,137											

N/G = Not Given, P = Pass

Table 6f. Data on Vulcan Chemicals

Unit 119

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
119	05/26/95	530,070	14.50	N/G	P	0	N/G	23	5	10	1	3	4
119	06/25/95	548,086	14.70	N/G	P	0	N/G	37	12	9	1	3	5
119	07/22/95	566,418	13.40	N/G	P	0	N/G	50	16	22	2	6	9
119	08/17/95	583,429	14.60	N/G	P	0	N/G	29	15	13	5	9	6
119	09/18/95	602,853	14.00	N/G	P	0	N/G	58	15	28	9	10	6
119	10/14/95	621,032	13.60	N/G	P	0	N/G	40	22	9	3	3	3
		Averages	14.1					40	14	15	4	6	6
		Std Dev	0.5					12	5	7	3	3	2
Ave. Hours Per Filter Change		18,192											

N/G = Not Given, P = Pass

Table 6g. Data on Vulcan Chemicals

Unit 120

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
120	06/03/95	512,727	14.70	N/G	P	0	N/G	28	1	10	0	2	2
120	07/02/95	527,457	14.70	N/G	P	0	N/G	46	7	8	1	4	5
120	07/16/95	536,033	14.70	N/G	P	0	N/G	44	6	8	3	5	5
120	08/27/95	560,184	16.60	N/G	P	0	N/G	29	3	16	7	8	9
120	09/23/95	574,914	14.50	N/G	P	0	N/G	44	7	20	8	10	16
120	10/20/95	589,645	14.50	N/G	P	0	N/G	27	20	16	1	2	8
		Averages	14.95					36	7	13	3	5	8
		Std Dev	0.74					8	6	5	3	3	4
Ave. Hours Per Filter Change		14,730											

N/G = Not Given, P = Pass

Table 6h. Data on Vulcan Chemicals

Unit 121

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
121	06/17/95	516,941	14.50	N/G	P	0	N/G	20	2	11	0	1	4
121	07/09/95	534,395	13.70	N/G	P	0	N/G	24	8	7	1	3	4
121	08/17/95	551,849	14.00	N/G	P	0	N/G	13	4	2	6	6	3
121	09/09/95	569,303	14.50	N/G	P	0	N/G	13	1	12	8	5	6
121	10/11/95	586,758	16.10	N/G	P	0	N/G	33	12	9	6	7	8
121	11/05/95	604,212	14.90	N/G	P	0	N/G	38	11	0	2	2	15
		Averages	14.60					24	6	7	4	4	7
		Std Dev	0.80					9	4	4	3	2	4
Ave. Hours Per Filter Change		17,212											

N/G = Not Given, P = Pass

Table 6i. Data on Vulcan Chemicals

Unit 122

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
122	05/14/95	491,209	15.40	N/G	P	0	N/G	33	12	23	7	7	11
122	06/11/95	504,509	13.80	N/G	P	0	N/G	51	7	15	1	1	6
122	08/08/95	540,223	15.10	N/G	P	0	N/G	77	11	11	4	6	8
122	09/08/95/	554,253	15.00	N/G	P	0	N/G	69	6	22	6	8	9
122	10/01/95	569,020	14.60	N/G	P	0	N/G	23	9	0	8	6	10
122	10/29/95	583,787	16.10	N/G	P	0	N/G	28	14	14	5	1	8
		Averages	15.00					47	10	14	5	5	9
		Std Dev	0.70					21	3	8	2	3	2

Ave. Hours Per Filter Change 18,516

N/G = Not Given, P = Pass

Table 6j. Data on Vulcan Chemicals

Unit 123

Unit #	Date	Miles On Oil	Viscosity, CsT-210F	Solid, %	Water, %	Fuel Dilution, %	Varnish %	Iron ppm	Copper ppm	Lead ppm	Chromium ppm	Aluminum ppm	Silicon ppm
123	05/13/95	482,744	13.90	N/G	P	0	N/G	21	9	11	7	6	12
123	06/12/95	499,786	13.70	N/G	P	0	N/G	25	5	14	2	1	6
123	08/07/95	534,460	14.70	N/G	P	0	N/G	47	7	16	4	6	7
123	09/03/95	550,794	14.20	N/G	P	0	N/G	42	5	11	6	9	9
123	10/01/95	567,836	14.30	N/G	P	0	N/G	64	12	18	8	10	7
123	10/29/95	602,510	14.50	N/G	P	0	N/G	28	13	4	2	2	5
		Averages	14.20					38	9	12	5	6	8
		Std Dev	0.30					15	3	4	2	3	2

Ave. Hours Per Filter Change 23,953

N/G = Not Given, P = Pass

Table 7. Data on Vulcan Chemicals Dyno Test

Unit 114

Hours	0.00	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75
HP	0	1	315	340	322	320	323	327	333	0
Speed	0	47	55	50	51	50	49	52	51	7

Unit 115

Hours	0.00	0.30	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50
HP	0	11	342	338	337	341	342	340	347	341	340	336	332	338
Speed	0	60	52	53	52	52	52	52	52	51	51	51	50	51

Unit 116

Hours	0.00	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
HP	0	3	341	335	336	331	332	339	0	0
Speed	0	60	53	53	52	52	52	55	14	0

Unit 117

Hours	0.00	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
HP	0	66	331	324	324	325	325	324	322	325	326	328	0
Speed	0	60	53	52	52	52	52	52	52	52	52	53	13

Unit 118

Hours	0.00	0.75	1.50	2.25	3.00	3.75	4.50
HP	0	14	320	334	335	341	1
Speed	0	69	52	52	52	52	24

Unit 119

Hours	0.00	0.30	1.00	121	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50
HP	0	5	330	338	340	339	342	341	338	332	344	341	338	0
Speed	0	60	53	50	51	51	50	50	50	50	51	50	50	11

Unit 120

Hours	0.00	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00
HP	0	328	315	312	316	322	311	318	0
Speed	0	53	52	52	52	52	57	55	0

Unit 121

Hours	0.00	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50
HP	0	0	10	322	340	337	338	341	336	336	339	339	343	340
Speed	0	11	60	56	53	52	52	52	52	52	52	53	52	52

Unit 122

Hours	0.00	0.30	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
HP	0	0	3	316	325	327	327	304	326	324	328	329	328
Speed	0	18	60	55	52	52	51	52	52	53	53	53	53

Unit 123

Hours	0.00	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00
HP	0	66	331	324	324	325	325	324	322	325	326	328	0
Speed	0	51	60	52	53	52	50	48	52	51	52	32	0

Figure

Schematic of the Onboard Oil Management System

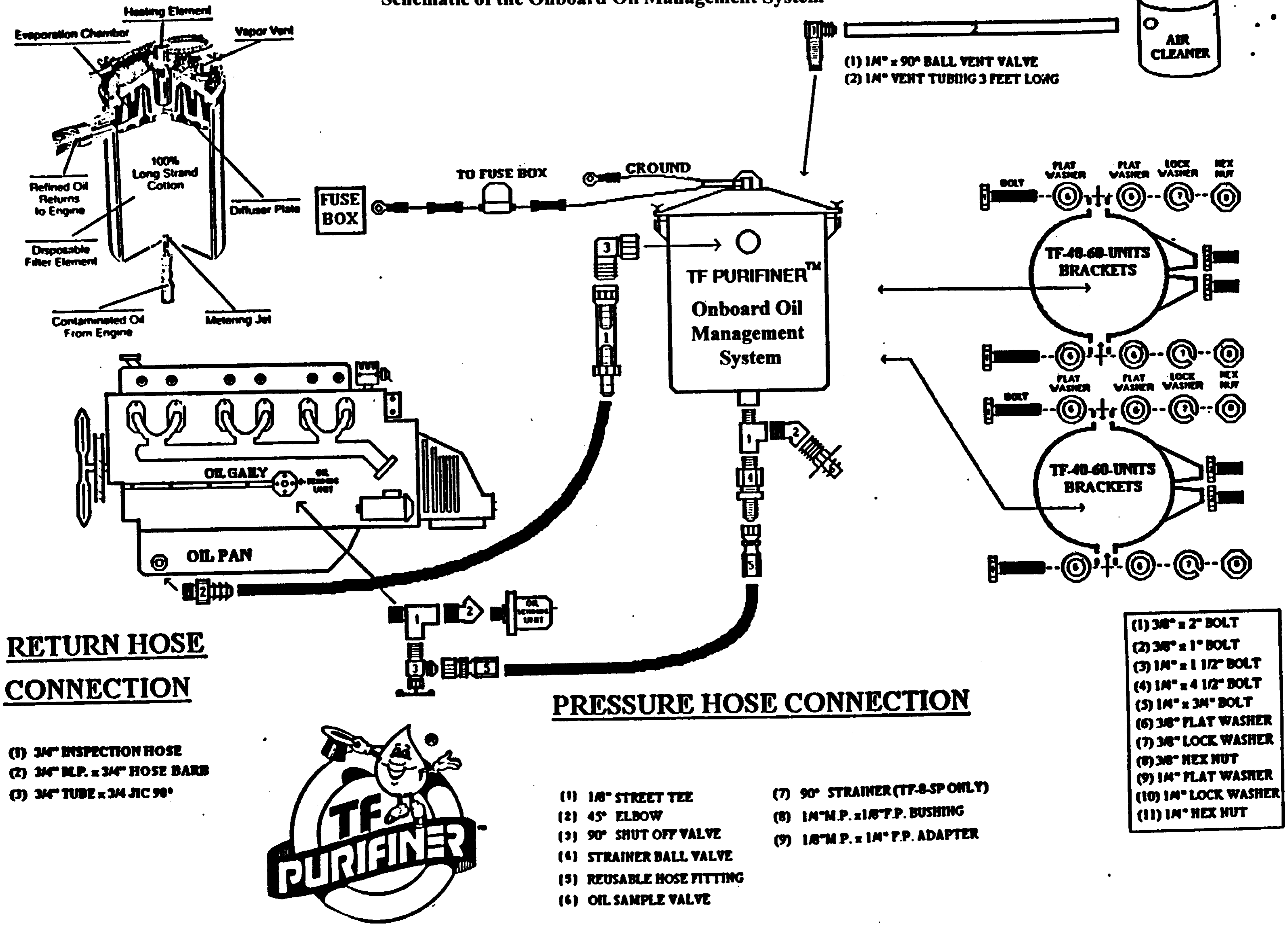


Figure 2 (from the 1994 evaluation report). Comparison of oil consumption and average miles on oil for engines with and without an Onboard Oil Management System.

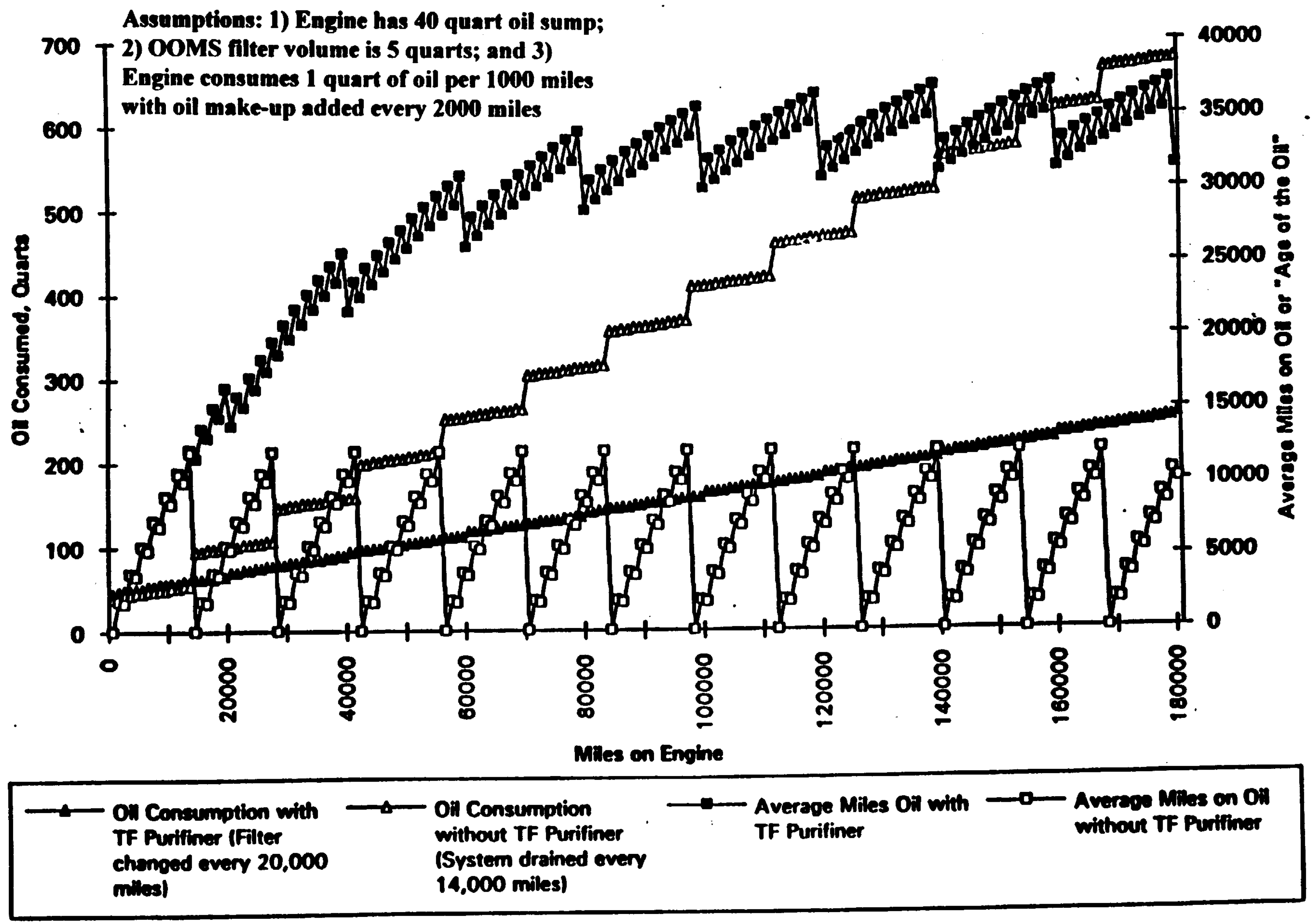
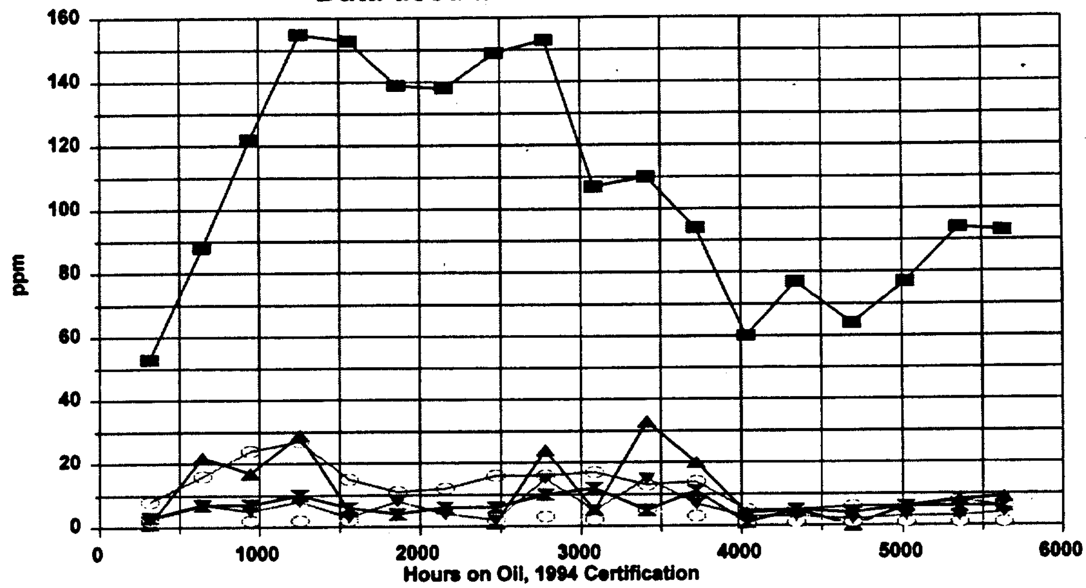
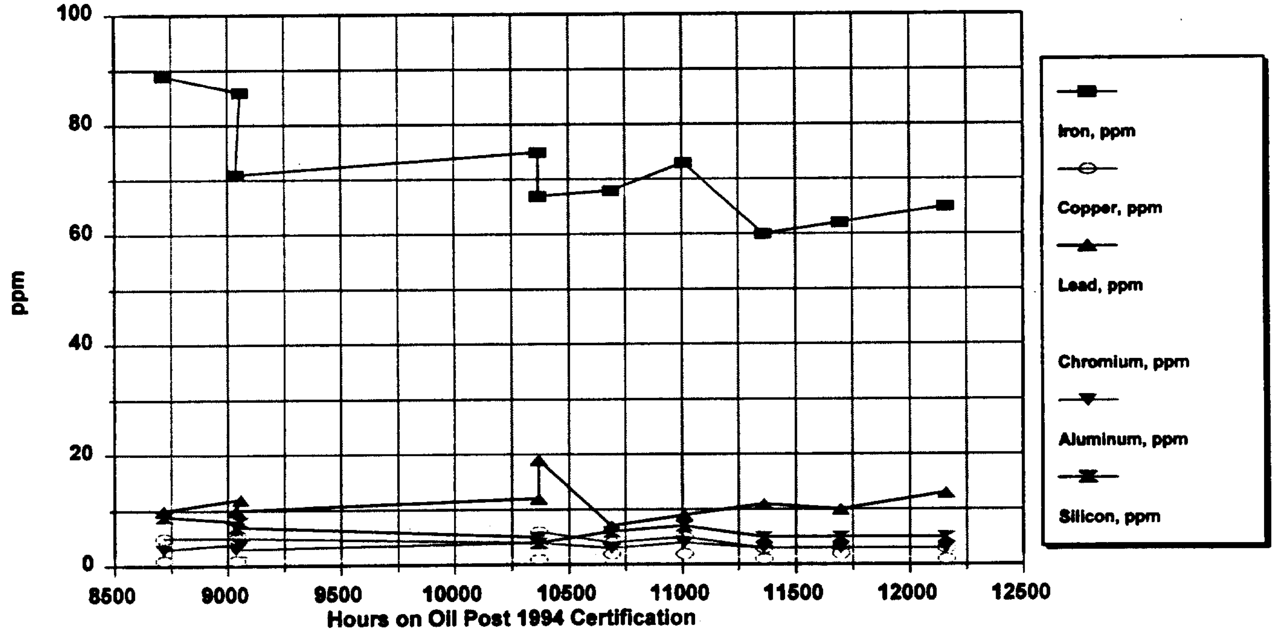


Figure 3a. Crumm Trucking, Unit 22
Data used in 1994 Certification



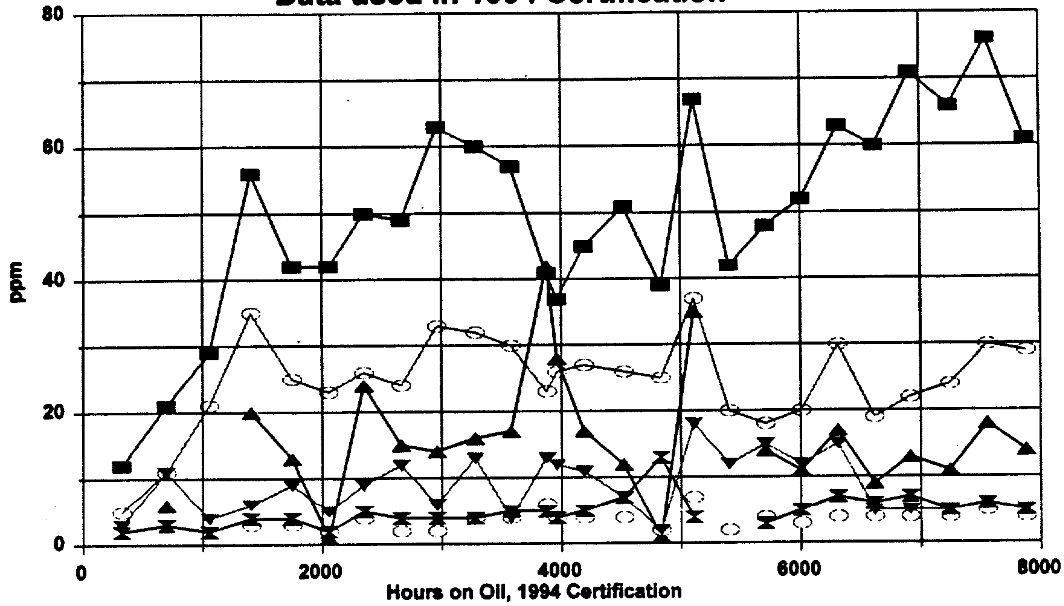
Represents data from the 1994 Certication

Figure 3b. Crumm Trucking, Unit 22
From 4/26/94 to 9/03/96



Crumm Trucking, long-time customer of TF Purifiner since 1988, had TF Purifiner' s OOMS intalled on each of their vehicles and never drained the oil from their engines. Data on two of Crumm Trucks are displayed in Figure 3a, 3b, 4a and 4b. All data provided stayed within the criteria for particles, water content, fuel content, and viscosity range. Warning limits and typical oil properties obtained from the outside consultants that are summarized, see Table 1. Figure 3a represents contaminant levels used for the 1994 Certification and Figure 3b represents contaminant levels data used after the 1994 Certification and into late 1996. NOTE: The legend at the right of last figure on each page describes each line. It should also be noted that each figure may have different ppm ranges as well as hours on each engine.

Figure 4a. Crumm Trucking, Unit 26 Data used in 1994 Certification



Represents data from the 1994 Certication

Figure 4b. Crumm Trucking, Unit 26 From 3/23/94 to 2/21/96

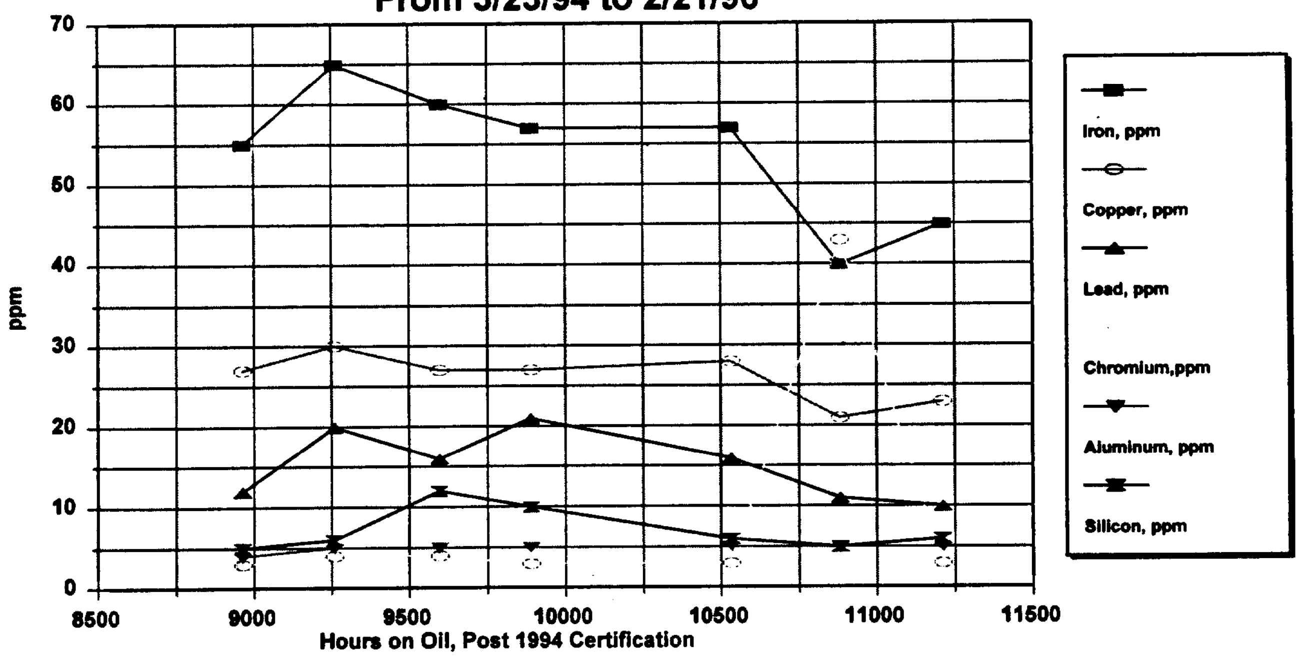
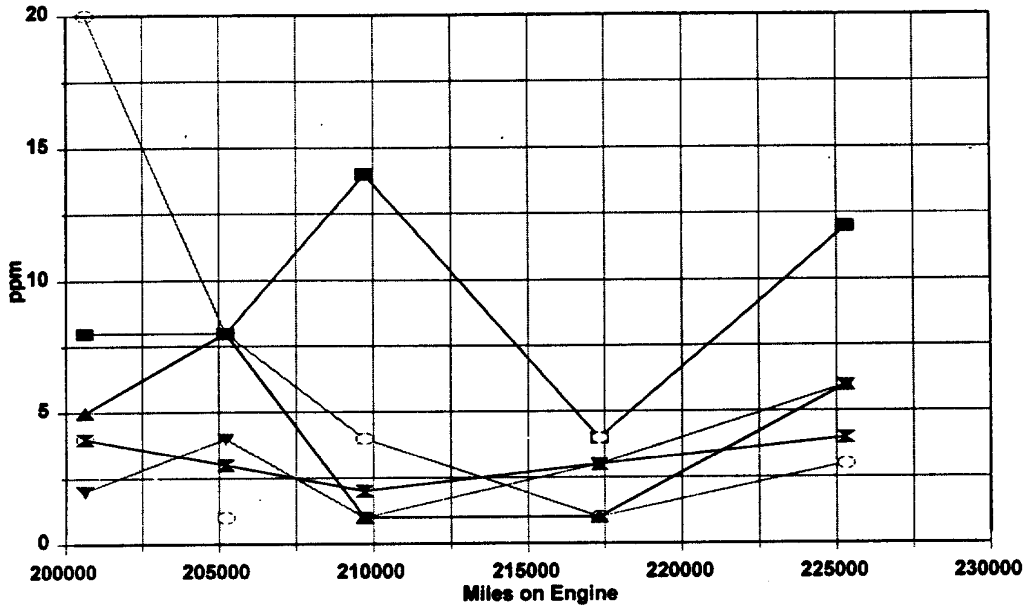
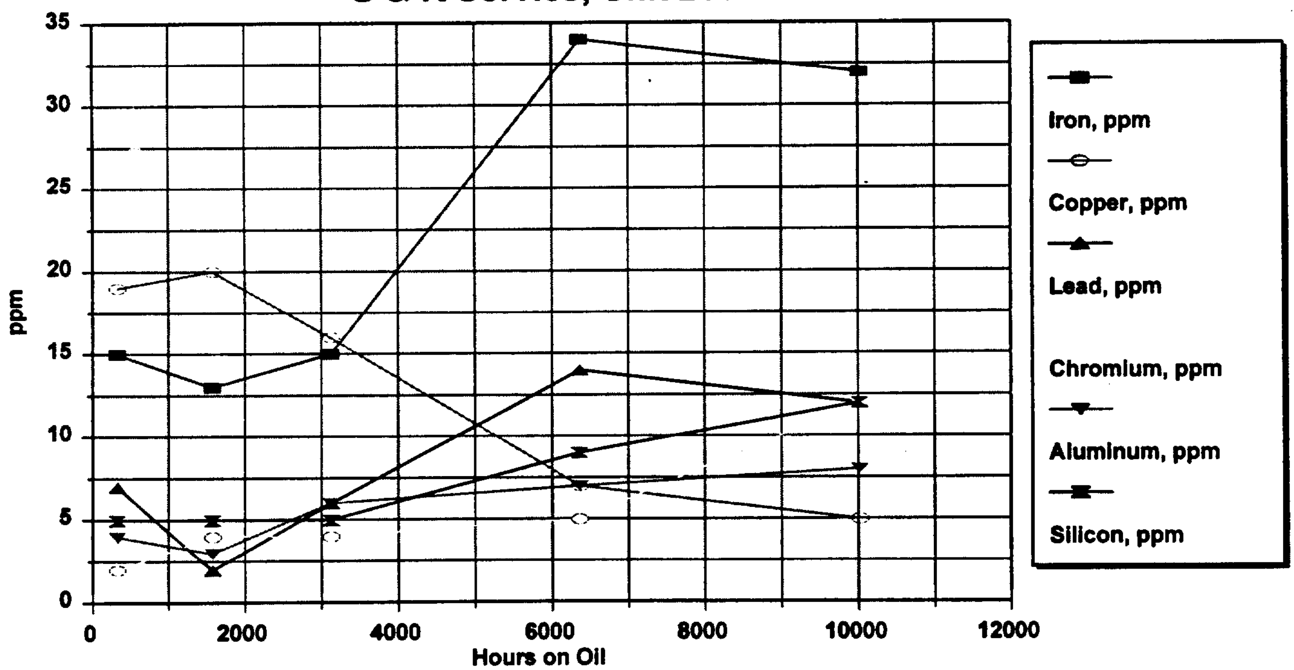


Figure 5a. Graph of Data from G & K Services, Unit 1683



Represents data from the 1994 Certification

Figure 5b. Graph of Data from G & K Servies, Unit 211



All data provided stayed within the criteria for particles, water content, fuel content, and viscosity range, except when caused by a system failure such as a stuck or clogged injector. Contaminant warning limits and typical oil properties obtained from the outside consultants are summarized, see Table 1. NOTE: The legend at the right of bottom figure describes each line. It should also be noted that each figure may have different ppm ranges as well as miles on engine.

Figure 6a. Data on Vulcan Chemicals Unit 114

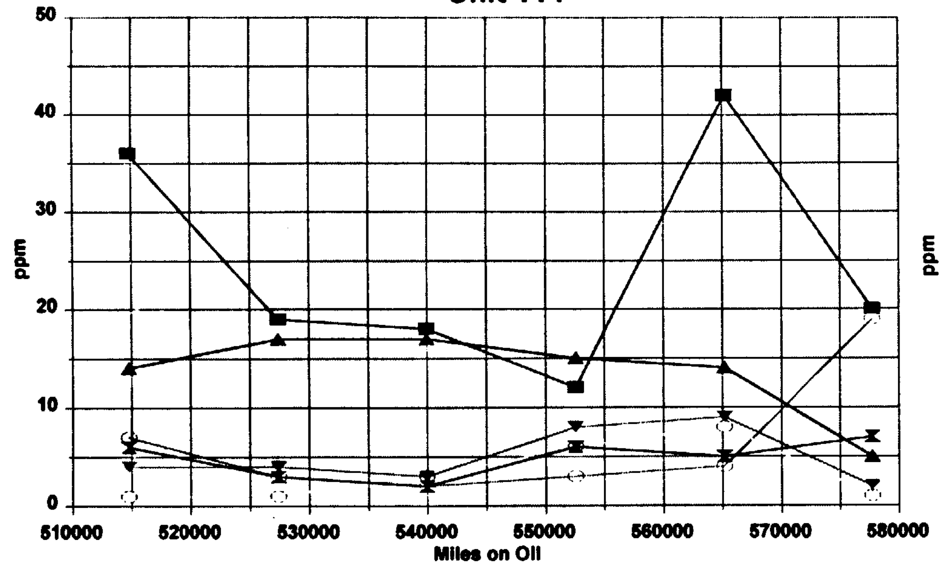


Figure 6b. Graph of Vulcan Chemicals Unit 115

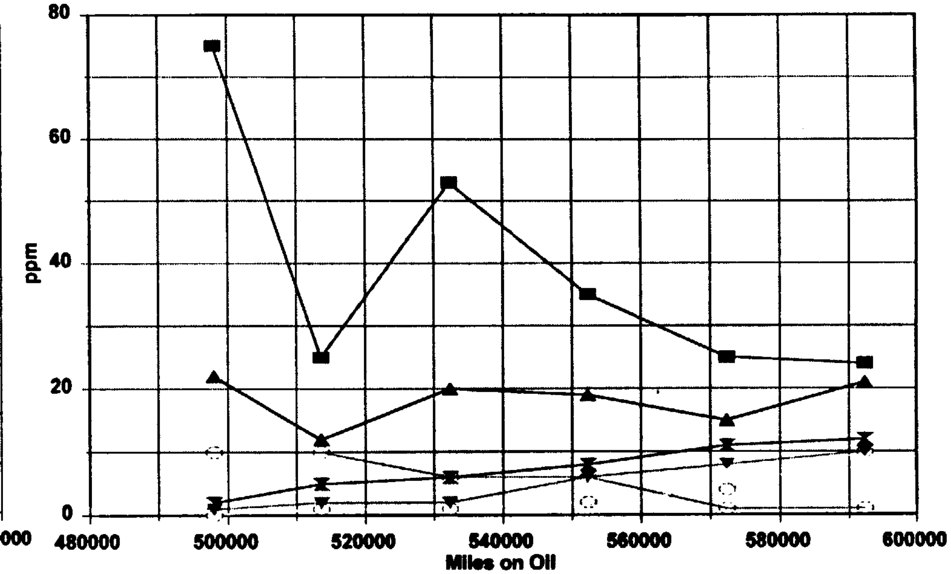


Figure 6c. Graph of Vulcan Chemicals Unit 116

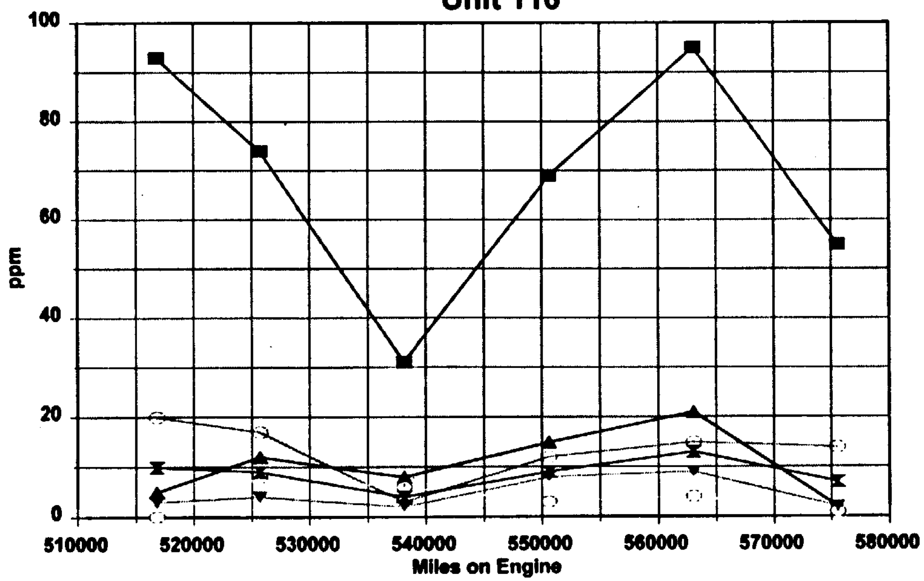


Figure 6d. Graph of Vulcan Chemicals Unit 117

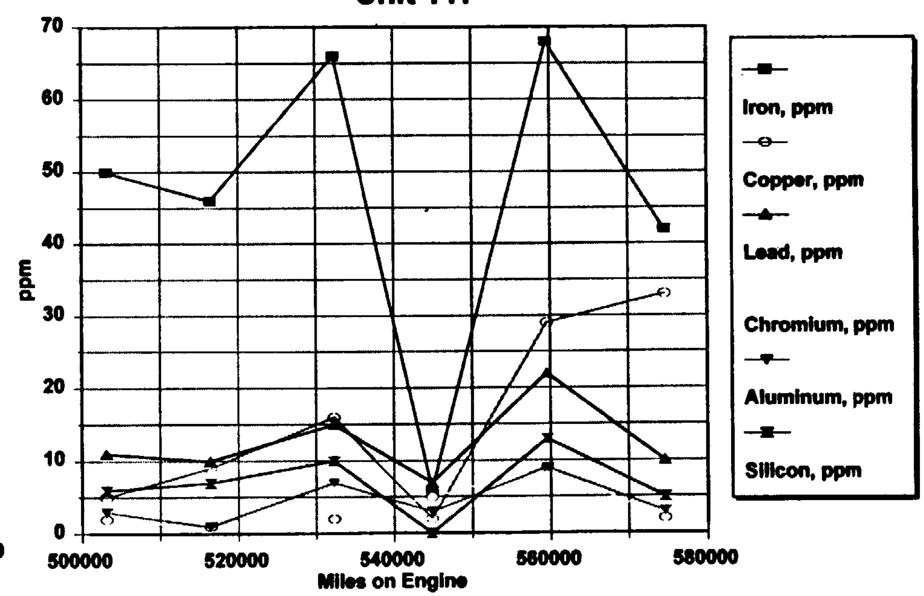


Figure 6e. Data on Vulcan Chemicals Unit 118

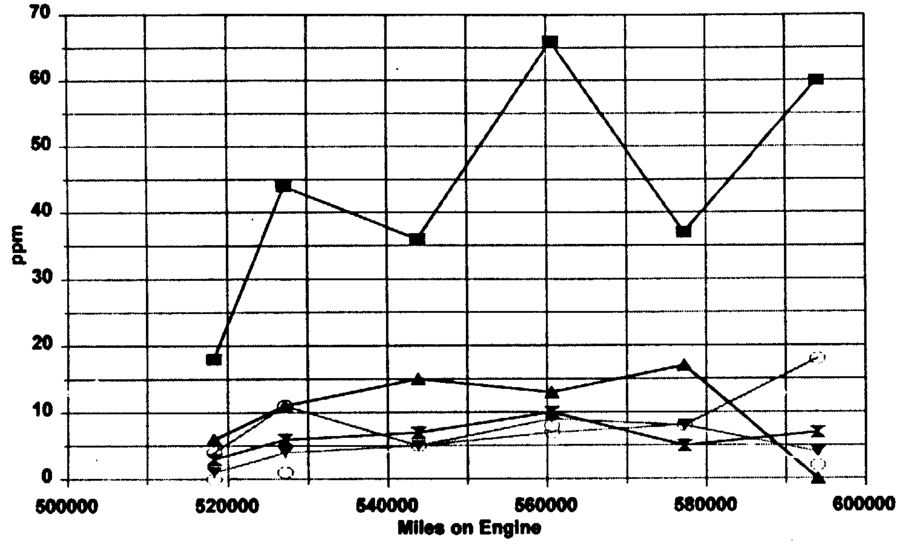


Figure 6f. Graph of Vulcan Chemicals Unit 119

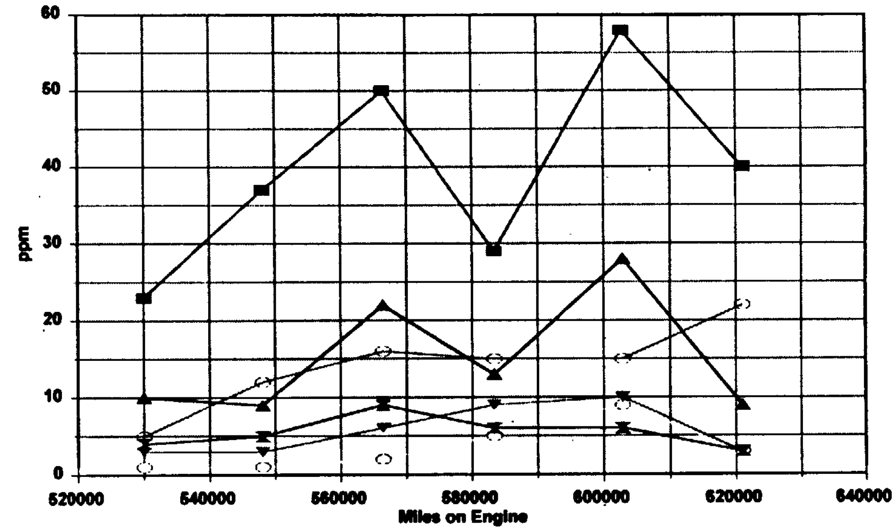


Figure 6g. Graph of Vulcan Chemicals Unit 120

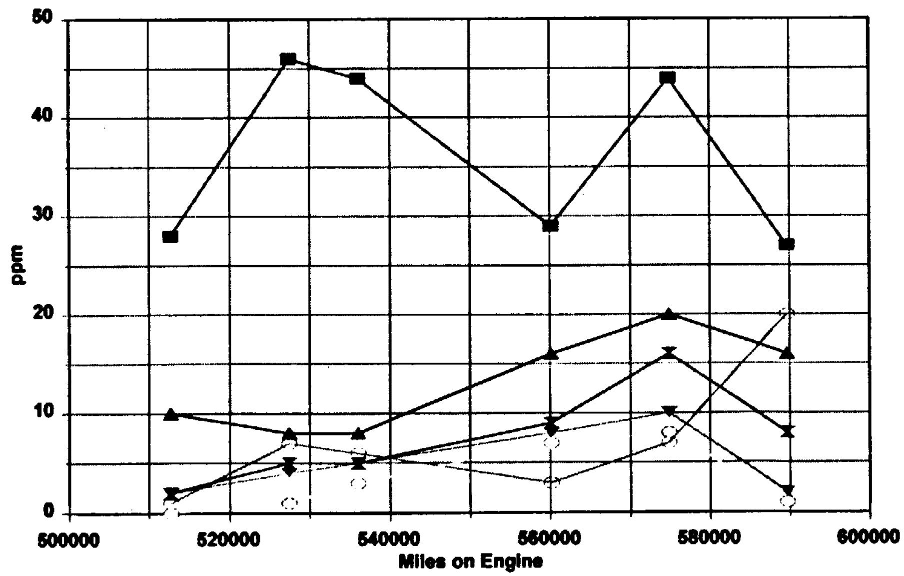


Figure 6h. Graph of Vulcan Chemicals Unit 121

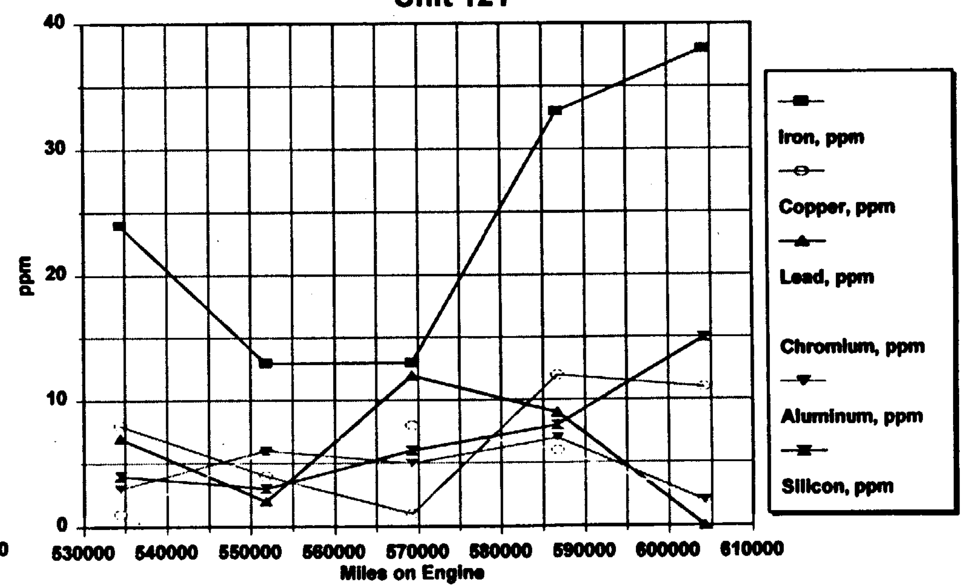


Figure 6i. Graph of Vulcan Chemicals Unit 122

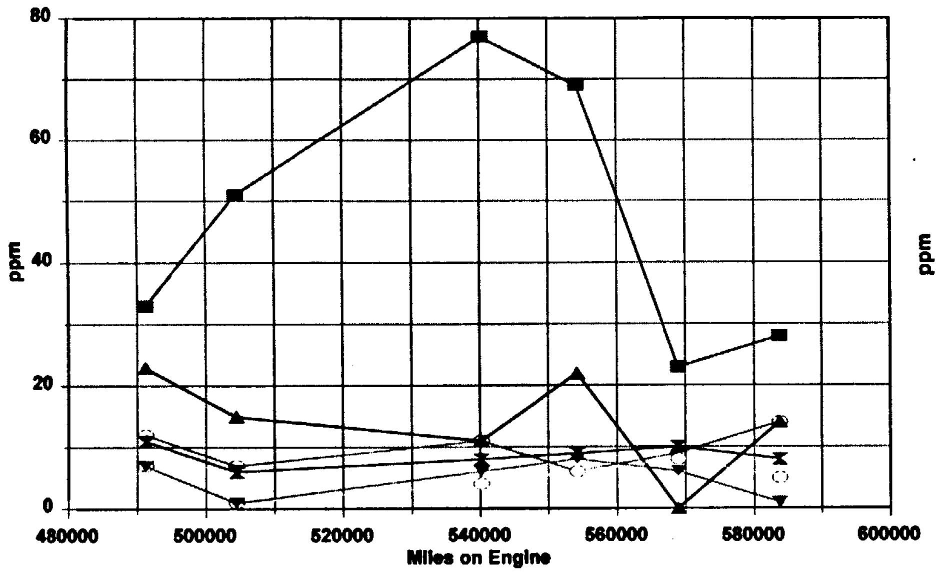
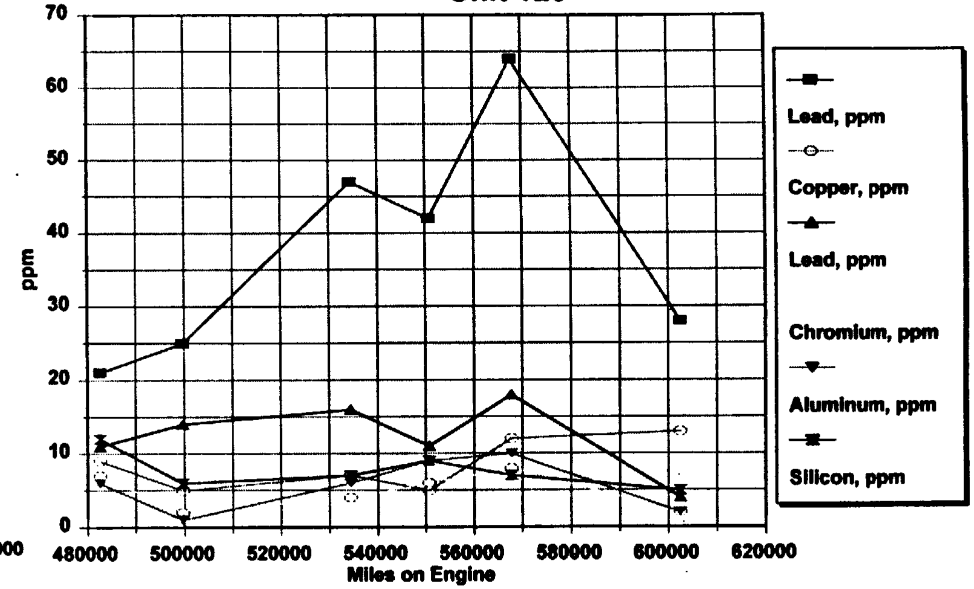


Figure 6j. Graph of Vulcan Chemicals Unit 123



There is a legend at the right of last figure on each page which describes each line. It should be noted that each figure may have different ppm ranges as well as miles on engine. For warning limits and typical oil properties obtained from the outside consultants that are summarized, see Table 1.

In 1992, Vulcan Chemicals leased ten trucks with Caterpillar 3406 engines. The oil samples taken, ranged with mileage from 12,000 to 24,000 miles per month. The oil analysis reports ranged from four to six months with a total of six samples per truck. Oil analysis reports were obtained near the end of the lease cycle with about 600,000 miles on each truck. All oil analysis reports stated ALL LEVELS APPEAR NORMAL for the reported periods. Oil changes ranged from a minimum of two to a maximum of five over the life of service. Vulcan Chemicals reports that in most cases, oil was changed for other reasons than being required by oil analysis. Several of the oil sample reports for Vulcan Chemicals had mileage gaps. Because of the consistent date intervals of samples and for graphical purposes above, missing mileage was interpollated to help fill in those gaps. For oil analysis reports see 1998 Volume II, Appendix B.

Figure 7a. Graph of Vulcan Chemicals
Unit 114-Horse Power vs Time

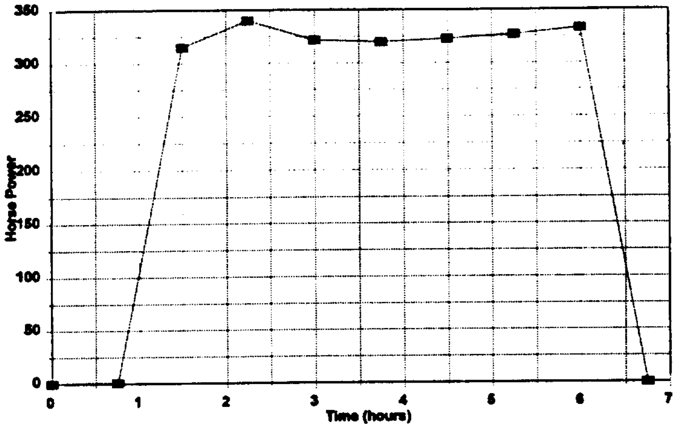


Figure 7b. Graph of Vulcan Chemicals
Unit 115-Horse Power vs. Time

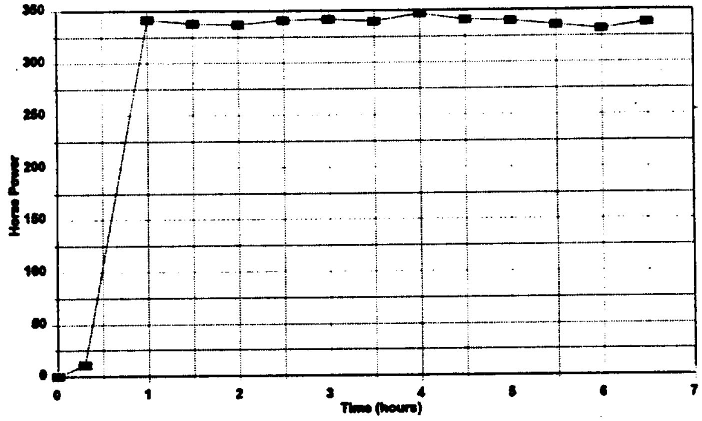


Figure 7c. Graph of Vulcan Chemicals
Unit 116-Horse Power vs. Time

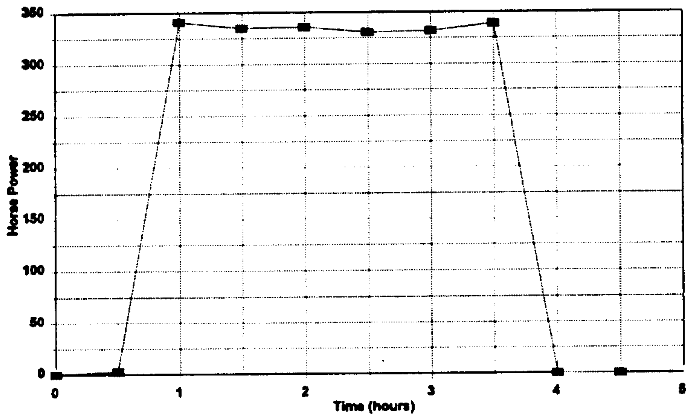


Figure 7d. Graph of Vulcan Chemicals
Unit 117 - Horse Power vs. Time

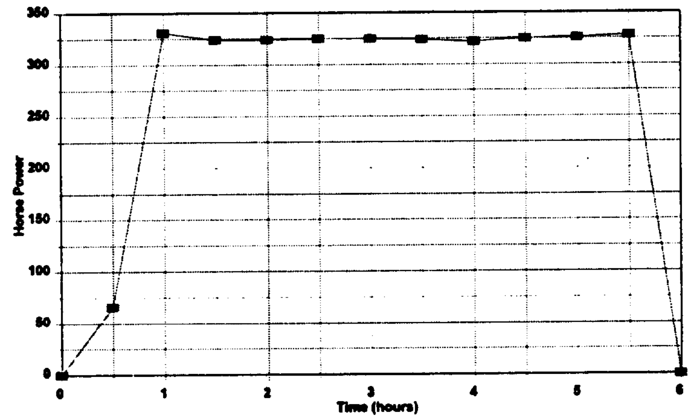


Figure 7e. Graph of Vulcan Chemicals
Unit 118 - Horse Power vs. Time

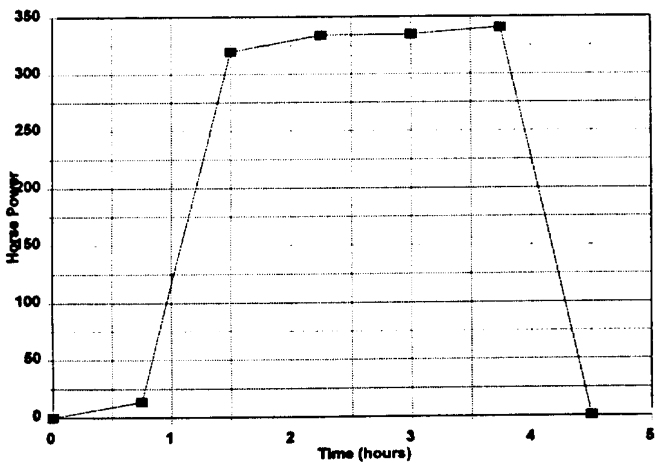
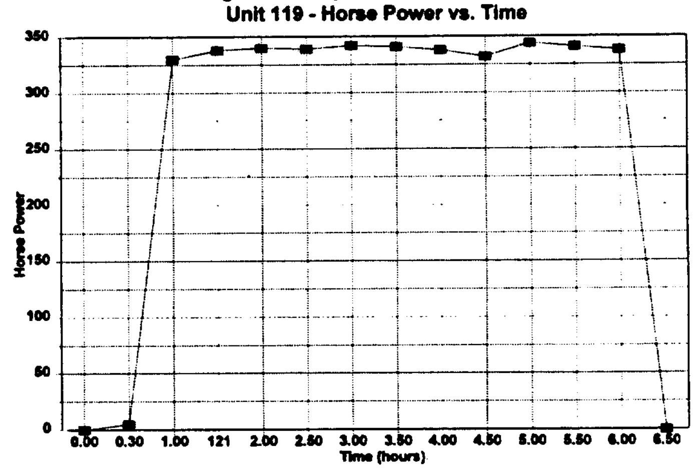


Figure 7f. Graph of Vulcan Chemicals
Unit 119 - Horse Power vs. Time



Rear wheel speed @ 50 miles per hour + or - 5 miles per hour

Figure 7g. Graph of Vulcan Chemicals Unit 120 - Horse Power vs. Time

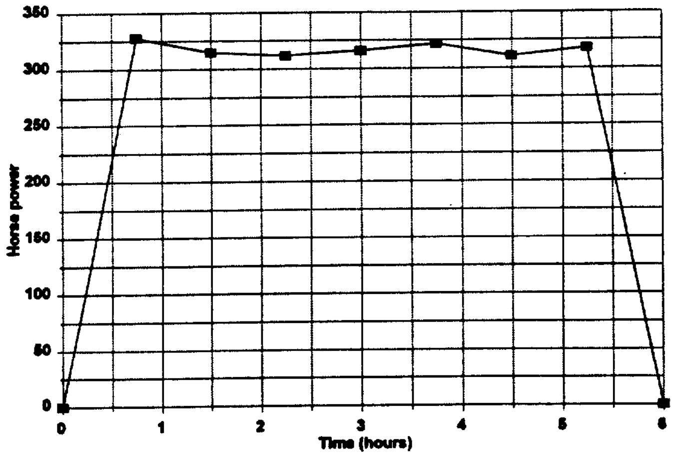


Figure 7h. Graph of Vulcan Chemicals Unit 121 - Horse Power vs. Time

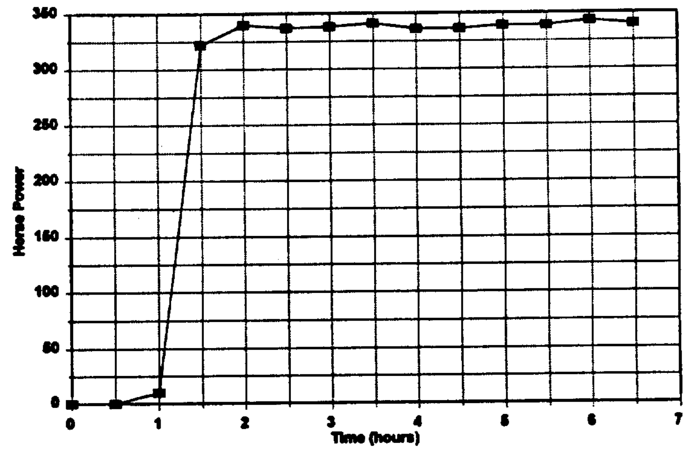


Figure 7i. Graph of Vulcan Chemicals Unit 122 - Horse Power vs. Time

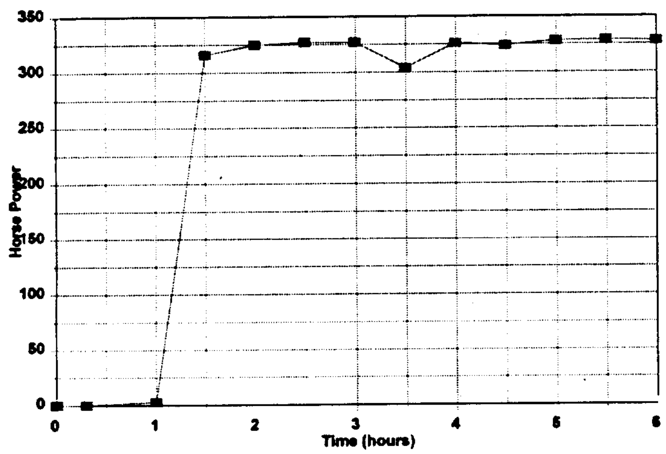
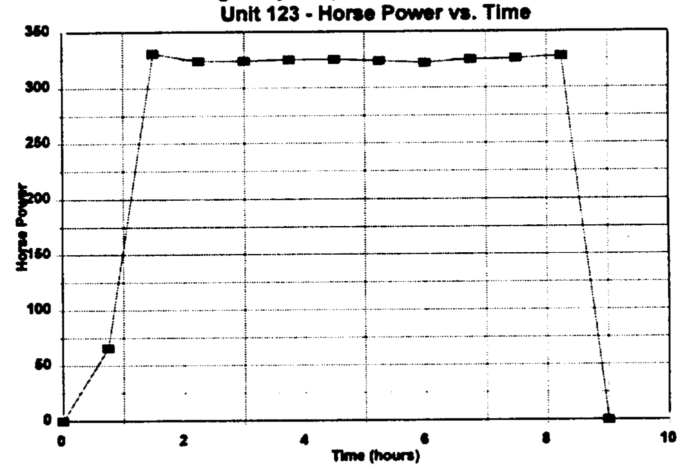


Figure 7j. Graph of Vulcan Chemicals Unit 123 - Horse Power vs. Time



Rear wheel speed @ 50 miles per hour + or - 5 miles per hour

In 1992, Vulcan Chemicals leased ten new trucks with Caterpillar 3406 engines. At the end of the lease, each truck had gone about 600,000 miles. Prior to returning the leased trucks, a dynamometer test was performed. All horse power engine performances were reached by the dynamometer test. One engine test was cut short because of engine overheating due to a faulty fan clutch. See Figures above for a graphic presentation on each truck engine for hours on the dynamometer, sustained horse power, and velocity maintained during the test.

The California Environmental Technology Certification Program

The California Environmental Protection Agency (Cal/EPA) offers a voluntary certification program for manufacturers and developers of environmental technologies who claim that their product offers a benefit to the environment.

The California Environmental Technology Certification Program (CalCert) began operating in 1994 following the adoption of authorizing law that was championed by business, industry, academic, legal, financial, and public interest stakeholders. The program evaluates hazardous waste prevention, measurement and remediation, air pollution control, and water and wastewater treatment technologies.

CalCert offers participating technology manufacturers and developers an independent, recognized third-party evaluation of the performance or attributes of new and mature environmental technologies. The technologies, equipment, and products that are proven to work as claimed receive official state certification valid for a three-year period, with the ability to renew every three years. Companies participating in the program pay the costs of evaluating their data and certifying their technologies.

Cal/EPA has issued over 100 certificates for equipment, devices, and processes for measurement and monitoring, site characterization, pollution prevention, and waste treatment.

California environmental technology certification is assurance of:

technology performance...

competitive advantage...

and international recognition.

For more information, please contact:

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www.calepa.ca.gov/calcert
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